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ABSTRACT

The rate training manual and nonresident career course presents materials for individualized study that will assist Aviation Structural Mechanics in Hydraulics (AMH) in meeting the occupational requirements of their rating. The study materials seek to improve job skills among Navy petty officers in conjunction with their on-the-job training as well as to aid the AMH2 in preparing for advancement to AMH1 and the AMH1 in preparing for advancement to AMH Chief. The following subject areas are covered in the 11 chapters of the text: (1) AMH rating, (2) work center supervision and administration, (3) aviation supply, (4) corrosion control, (5) nondestructive inspection of metals, (6) power system maintenance, (7) brake system maintenance, (8) landing gear maintenance, (9) flight control system maintenance, (10) actuating system maintenance, and (11) general hydraulic system maintenance. Many explanatory diagrams are included. A discussion of the metric system and a conversion table are appended. An index is included. A list of minimum qualifications for advancement to AMH1 and Chief is provided. A 59-page section presents eight assignments for the nonresident career course which are based on the materials in the text. (Author/EC)

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AVIATION

STRUCTURAL MECHANIC H 1 & C

NAVAL EDUCATION AND TRAINING COMMAND

RATE TRAINING MANUAL
AND NONRESIDENT CAREER COURSE

NAVEDTRA 10313-C

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PREFACE

The ultimate purpose of training Naval personnel is to produce a combatant Navy which can ensure victory at sea. A consequence of the quality of training given them is their superior state of readiness. Its result is a victorious Navy.

This Rate Training Manual and Nonresident Career Course (RTM/NRCC) form a self-study package that will enable ambitious Aviation Structural Mechanics (H) to help themselves fulfill the requirements of their rating.

Designed for individual study and not formal classroom instruction, the RTM provides subject matter that relates directly to the occupational qualifications of the Aviation Structural Mechanic H (AMH) rating. The NRCC provides the usual way of satisfying the requirements for completing the RTM. The set of assignments in the NRCC includes learning objectives and supporting items designed to lead students through the RTM.

This training manual and nonresident career course was prepared by the Naval Education and Training Program Development Center, Pensacola, Florida, for the Chief of Naval Education and Training. Technical review of the manuscript was provided by personnel of the AMH (B) School, NAS Memphis, Millington, Tennessee, and the Naval Aviation Integrated Support Center, Patuxent River, Maryland. Technical assistance was also provided by the Naval Air System Command.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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CHAPTER 1

AVIATION STRUCTURAL MECHANIC H RATING

An important training objective, which is met in part by using this Rate Training Manual, is the improvement of job skills among Navy petty officers. Achievement of this objective is made possible through the use of the manual as a study aid in conjunction with on-the-job training.

In addition to the objective stated above, this Rate Training Manual is designed to aid the AMH2 in preparing for advancement to AMH1 and the AMH1 in preparing for advancement to AMHC. It is based primarily on the professional requirements or qualifications for AMH1 and AMHC, as specified in the *Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards,* NAVPERS 18068(Series).

In preparing for advancement examinations, you should study this manual along with AMH 3&2, since some material on the examination for advancement may be thoroughly explained in that publication and not repeated in this manual.

In addition, *Military Requirements for Petty Officer 1&C,* NAVEDTRA 10057(Series), should also be studied. The latter manual covers naval requirements for all senior petty officers and additionally provides basic coverage on the Naval Aviation Maintenance Program.

ENLISTED RATING STRUCTURE

The present enlisted rating structure includes two types of ratings: general ratings and service ratings.

GENERAL RATINGS are designed to provide paths of advancement and career development. A general rating identifies a broad occupational field of related duties and functions requiring similar aptitudes and qualifications. General ratings provide the primary means used to identify billet requirements and personnel qualifications. Some general ratings include service ratings; others do not. Both Regular Navy and Naval Reserve personnel may hold general ratings.

Subdivisions of certain general ratings are identified as SERVICE RATINGS. These service ratings identify areas of specialization within the scope of a general rating. Service ratings are established in those general ratings in which specialization is essential for efficient utilization of personnel. Service ratings can exist at any petty officer level, but are most common at the PO3 and PO2 levels. Both Regular Navy and Naval Reserve personnel may hold service ratings.

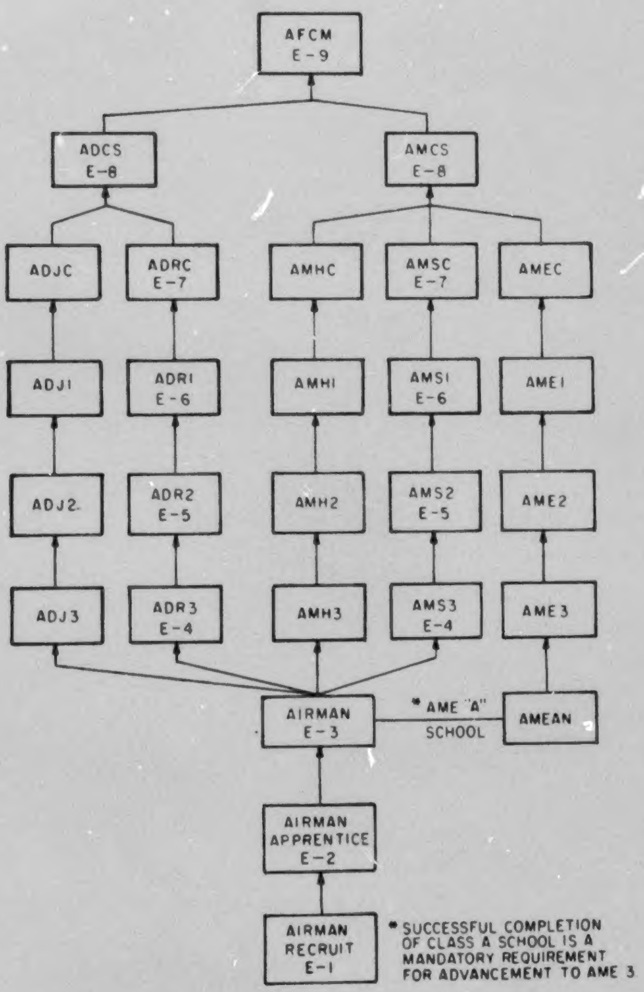
AVIATION STRUCTURAL MECHANIC (AM) RATING

The AM rating is divided into three service ratings at paygrades E-4 through E-7. The service ratings are AME (Safety Equipment), AMS (Structures), and AMH (Hydraulics).

At paygrade E-8 the general rating, AM, applies. Therefore, upon advancement to E-8, paygrade E-7 personnel (AMECs, AMSCs, AMHCs) are combined to become Senior Chief Aviation Structural Mechanics (AMCS).

At paygrade E-9, the AM rating loses its identity and personnel in the rating advance, along with ADCS, to Master Chief Aircraft Maintenanceman (AFCM).

Figure 1-1 illustrates all paths of advancement for an Airman Recruit to Master


AFCM
E-9
ADCS
E-8
AMCS
E-8
ADJC
ADRC
E-7
AMHC
AMSC
E-7
AMEC
ADJ1
ADR1
E-6
AMH1
AMS1
E-6
AME1
ADJ2
ADR2
E-5
AMH2
AMS2
E-5
AME2
ADJ3
ADR3
E-4
AMH3
AMS3
E-4
AME3
AIRMAN
E-3
* AME "A"
SCHOOL
AMEAN
AIRMAN
APPRENTICE
E-2
AIRMAN
RECRUIT
E-1
* SUCCESSFUL COMPLETION
OF CLASS A SCHOOL IS A
MANDATORY REQUIREMENT
FOR ADVANCEMENT TO AME 3

213.1

Figure 1-1.—Paths of advancement (Enlisted).

Chief Aircraft Maintenanceman. Figure 1-2 illustrates the paths of advancement to Warrant Officer (W-4), or to Limited Duty Officer (LDO).

The *Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards,* NAVPERS 18068(Series), states that the AMH is responsible for the maintenance of hydraulic systems, including auxiliary and main power systems, landing gear, brakes, related pneumatic systems, pumps, and all other hydraulically actuated systems and components.

The AMH1 must be qualified to supervise and direct aircraft inspections; maintain work center registers and/or visual information display system board and prepare associated reports;

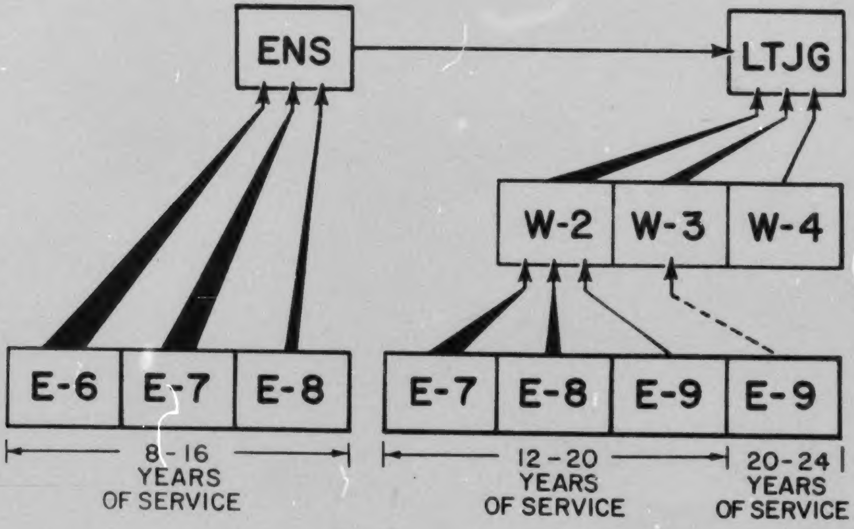


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Figure 1-2.—Paths of advancement (LDO/WO).

identify and order publications, parts, tools, and equipment; maintain current shop files of directives and other publications and maintain inventory records; perform and interpret magnetic particle inspections; use schematic diagrams, drawings, and charts in troubleshooting/malfunction analysis and prescribing appropriate corrective action; inspect installation of repaired or new parts and components; inspect, test, and adjust hydraulic control and actuating mechanisms; rig and adjust nosewheel steering mechanism; supervise landing gear drop checks; and check landing gear alignment.

In addition to the above listed requirements for AMH1, the AMHC must be qualified to analyze hydraulic and flight control system discrepancies and malfunctions and determine corrective action; analyze aircraft irregular flight characteristics and determine corrective action; determine repair procedures for damaged landing gear; determine the necessity and procedures for hydraulic fluid surveillance; be able to read and interpret daily and monthly maintenance data reports and manhour accounting reports (when applicable); know the procedures for hoisting aircraft; interpret directives from higher authority; schedule and assign workload; and maintain quality assurance of work performed. He should also be capable of preparing for advance base or forward area operations and organizing and administering a program of safety instruction applicable to AM personnel, equipment, and facilities.

In addition to the above listed qualifications, the AMH1 and AMHC should assist subordinates in preparing and meeting the qualifications for advancement.

A wide variety of assignments is available to the AMH1 and AMHC. In addition to the various types of maintenance activities to which lower rated personnel are assigned, the AMH1 and AMHC are eligible for assignment to instructor duty as well as a number of other desirable shore billets. Most of these billets are under the management control of NAVPERS and are directly associated with training. Others are associated with research, testing, or evaluation. Some of the more desirable billets to which the AMH1 and AMHC may be assigned are described in the following paragraphs.

The Naval Air Technical Training Center, NAS Memphis, Millington, Tennessee, has a large number of instructor billets as well as support billets at both the AMH1 and AMHC levels. Instructor billets are in the various AM courses as well as other aviation related courses.

The AMH1 and AMHC may be assigned to instructor duty with a Naval Air Maintenance Training Detachment. NAMTRADETs are located at shore stations on both coasts. Personnel assigned to this duty are first sent to Naval Air Maintenance Training Group headquarters at NAS Memphis, Millington, Tennessee, for a period of indoctrination and instruction.

Instructor billets are normally filled on a voluntary basis. Detailed information concerning assignment to instructor duty is contained in the *Enlisted Transfer Manual*, NAVPERS 15909 (Series).

Senior Chief Aviation Structural Mechanics are eligible for assignment to duty with the Naval Education and Training Program Development Center, Pensacola, Florida, as Technical Writers. Personnel assigned to these billets assist in preparing and/or revising Rate Training Manuals and Nonresident Career Courses for the AMS, AMH, and AME ratings.

Chief Aviation Structural Mechanics, Senior Chief Aviation Structural Mechanics, and Master Chief Aircraft Maintenancemen are also eligible for assignment to duty with the Naval Education and Training Program Development Center as Technical Writers. Personnel assigned to these Billets assist in the preparation of Navy-wide advancement examinations for the AMS, AMH, and AME ratings.

Enlisted personnel may be assigned to a number of special programs, such as reserach, testing, or evaluation. An example is an assignment with the Naval Aviation Integrated Logistics Support Center (NAILSC), NATC, Patuxent River, Maryland. Their mission is to develop the elements necessary to assure effective and economical support of a specific weapon system or equipment at all levels of maintenance for its programmed life cycle. The mission encompasses logistics support in a broad sense and includes areas such as money, manpower, and materials necessary to provide the operating forces with the capability needed to keep the weapon system or equipment in a functioning status.

For a listing of other special programs and projects, refer to the *Enlisted Transfer Manual.* Others are also announced from time to time in BUPERS Notices.

Personnel may indicate their desire for assignment to a specific program or project in the "remarks" block of their Rotation Data Card.

As a petty officer, you are already aware of the importance of the AMH rating to naval aviation. Pilots and aircrewmen depend upon the AMH for the efficient operation of the flight controls systems, landing gear, and other hydraulic-operated systems. As higher and higher aircraft speeds and altitudes are attained, improved hydraulic system components are developed. Thus, the AMH's job involves new and greater responsibilities; and from the lowest level up, he must possess greater technical skills than ever.

When advanced to AMH1 and AMHC, you will assume more responsibility. As a senior petty officer, you must possess more than technical skills. You must assume greater responsibility not only for your own work, but also for the work of others who serve under you. Briefly, you the AMH1 and AMHC must be a skilled mechanic, supervisor, inspector, and instructor, as well as an accomplished military leader.

ADVANCEMENT

By this time, you are probably well aware of the personal advantages of advancement–higher pay, greater prestige, more interesting and challenging work, and the satisfaction of getting ahead in your chosen career. By this time, also, you have probably discovered that one of the most enduring rewards of advancement is the training you acquire in the process of preparing for advancement.

The Navy also profits by your advancement. Highly trained personnel are essential to the functioning of the Navy. By advancement, you increase your value to the Navy in two ways: First, you become more valuable as a person who can supervise, lead, and train others; and second, you become more valuable as a technical specialist who can thus make far-reaching contributions to the entire Navy.

Since you are studying for advancement to PO1 or CPO, you are probably already familiar with the requirements and procedures for advancement. However, you may find it helps to read the following sections. The Navy does not stand still. Things change all the time, and it is possible that some of the requirements have changed since the last time you went up for advancement. Furthermore, you will be responsible for training others for advancement; therefore, you will need to know the requirements in some detail.

HOW TO QUALIFY FOR ADVANCEMENT

To qualify for advancement, a person must:

1. Have a certain amount of time in grade.
2. Complete the required Rate Training Manuals by passing either a locally prepared and administered test or the Nonresident Career Course based on the Rate Training Manual.
3. Demonstrate the ability to perform all the PRACTICAL requirements for advancement by completing applicable portions of the *Record of Practical Factors,* NAVEDTRA 1414/1(AM).
4. Be recommended by your commanding officer, after the petty officers and officers supervising your work have indicated that they consider you capable of performing the duties of the next higher rate.
5. Demonstrate KNOWLEDGE by passing a written examination on (a) military requirements, and (b) professional qualifications.

Remember that the requirements for advancement can change. Check with your educational services office to be sure that you know the most recent requirements.

When you are training lower-rated personnel, point out that advancement is not automatic. Meeting all the requirements makes a person ELIGIBLE for advancement, but does not guarantee advancement. Such factors as the score made on the written examination, length of time in service, performance marks, and quotas for the rating enter into the final determination of who will actually be advanced.

HOW TO PREPARE FOR ADVANCEMENT

What must you do to prepare for advancement? Advancement is not an overnight affair. You do not take the advancement examination and wake up in the morning in the next pay grade. You must pursue a path or sequence of events. Certain things must be done before you are admitted to take the advancement examination. You must study the qualifications for advancement, work on the practical factors, study the required Rate Training Manuals, and study other materials required for advancement. To prepare for advancement, you should be familiar with the purpose, use, and interrelationship of the following publications pertaining to the advancement process.

1. *Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards,* NAVPERS 18068(Series).
2. *Record of Practical Factors,* NAVEDTRA 1414/1(AM).
3. *Bibliography for Advancement Study,* NAVEDTRA 10052(Series).
4. Applicable Rate Training Manuals and their companion Nonresident Career Courses.

Collectively, these documents make up an integrated training package tied together by the qualifications. The following paragraphs describe these materials and give some information on how each one is related to the others.

"Quals" Manual

The *Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards,* NAVPERS 18068 (Series), gives the minimum requirements for advancement to each rate within each rating. This manual is usually called the "Quals" Manual, and the qualifications themselves are often called "quals." The qualifications are of two general types: (1) naval requirements, and (2) professional or technical qualifications. Naval requirements apply to all ratings rather to any one rating alone. Professional qualifications are technical or professional requirements that are directly related to the work of each rating. Both the naval requirements and the professional qualifications are divided into subject matter groups.

The qualifications for advancement and a bibliography of study materials are available in your educational services office. The "Quals" Manual is changed more frequently than Rate Training Manuals are revised. By the time you are studying this training manual, the "quals" for your rating may have been changed. Never trust any set of "quals" until you have checked the change number against an UP-TO-DATE copy of the "Quals" Manual.

In training others for advancement, emphasize these three points about the "quals":

1. The "quals" are the MINIMUM requirements for advancement. Personnel who study MORE than the required minimum will have a great advantage when they take the written examinations for advancement.
2. Each "qual" has a designated rate level–chief, first class, second class, or third class. You are responsible for meeting all "quals" specified for the rate level to which you are seeking advancement AND all "quals" specified for lower rate levels.
3. The written examinations for advancement will contain questions relating to the professional qualifications.

NOTE: At the time this manual was written, the Navy was in the process of replacing "Quals" with "Occupational Standards." As was already mentioned in this chapter, the "Quals" are revised more often than the Rate Training Manuals. Therefore, if you hear of "Occupational Standards" instead of "Quals" as you read this Rate Training Manual, keep in mind that the next revision will catch up with another change in Navy training. The new manual will be called the *Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards,* NAVPERS 18068 (Series).

Record of Practical Factors

Before you can take the Navy-wide examination for advancement, your service record must show that you have qualified in the practical factors of both the naval requirements and the professional qualifications. A special form known as the *Record of Practical Factors,* NAVEDTRA 1414/1 (plus the abbreviation of the appropriate rating), is used to keep a record of your practical factor qualifications. The form lists all practical factors, both military and professional. As you demonstrate your ability to perform each practical factor, appropriate entries are made in the DATE and INITIALS columns.

As a PO1 or CPO, you will often be required to check the practical factor performance of lower rated personnel and to report the results to your supervising officer.

As changes are made periodically to the "Quals" Manual, new forms of NAVEDTRA 1414/1 are provided when necessary. Extra space is allowed on the *Record of Practical Factors* for entering additional practical factors as they are published in changes to the "Quals" Manual. The *Record of Practical Factors* also provides space for recording demonstrated proficiency in skills which are within the general scope of the rating but which are not identified as minimum qualifications for advancement. Keep this in mind when you are training and supervising other personnel. If a person demonstrates proficiency in some skill which is not listed in the "quals" but which is within the general scope of the rating, report this fact to his supervising officer so that an appropriate entry can be made in the *Record of Practical Factors.*

When you are transferred, the *Record of Practical Factors* should be forwarded with your service record to your next duty station. Check and be sure that this form is actually inserted in your service record before you are transferred. If the form is not in your record, you may be required to start all over again and requalify in practical factors that have already been checked off. You should also take some responsibility for helping lower rated personnel keep track of their practical factor records when they are transferred.

A second copy of the *Record of Practical Factors* should be made available to each man in pay grades E-2 through E-8 for his personnel record and guidance.

The importance of NAVEDTRA 1414/1 cannot be overemphasized. It serves as a record to indicate to the petty officers and officers supervising your work that you have demonstrated proficiency in the performance of the indicated practical factors and is part of the criteria used by your commanding officer when he considers recommending you for advancement. In addition, the proficient demonstration of the applicable practical factors listed on this form can aid you in preparing for the examination for advancement.

NAVEDTRA 10052

Bibiliography for Advancement Study, NAVEDTRA 10052 (Series), a very important publication for anyone preparing for advancement, lists required and recommended Rate Training Manuals and other reference material to be used by personnel working for advancement. NAVEDTRA 10052 (Series) is revised and issued each year by Naval Education and Training Support Command. Each revised edition is identified by a letter following the NAVEDTRA number. Be SURE you have the most recent edition.

The required and recommended references are listed by rate level in NAVEDTRA 10052 (series). Remember that you are responsible for all references at lower rate levels, as well as those listed for the rate to which you are seeking advancement.

Rate Training Manuals marked with an asterisk (*) in NAVEDTRA 10052 (Series) are MANDATORY at the indicated rate levels. A mandatory training manual may be completed by (1) passing the appropriate Nonresident Career Course based on the mandatory training manual; (2) passing locally prepared tests based on the information given in the mandatory training manual; or (3) in some cases, successfully completing an appropriate Navy school.

When training personnel for advancement, do not overlook the section of NAVEDTRA 10052 (Series) which lists the required and recommended references to the naval requirements for advancement. All personnel must complete the mandatory naval requirements training manual for the appropriate rate level before they can be eligible to advance. Also, make sure that personnel working for advancement study the references listed as recommended but not mandatory in NAVEDTRA 10052 (Series). Remember that ALL references listed in NAVEDTRA 10052 (Series) may be used as source material for the written examinations, at the appropriate levels.

Rate Training Manuals

There are two general types of manuals. Rate Training Manuals (such as this one) are prepared for most enlisted rates and ratings and give information that is directly related to the professional qualifications for advancement. Subject matter manuals give information that applies to more than one rating.

Rate Training Manuals are revised from time to time to bring them up to date technically. The revision of a Rate Training Manual is identified by a letter following the NAVEDTRA number. You can tell whether a Rate Training Manual is the latest edition by checking the NAVEDTRA number (and the letter following the number) in the most recent edition of *List of Training Manuals and Correspondence Courses*, NAVEDTRA 10061 (Series). NAVEDTRA 10061 is a catalog that lists current training manuals and courses. You will find this catalog useful in planning your study program.

Rate Training Manuals are designed for the special purpose of helping naval personnel prepare for advancement. By this time, you have probably developed your own way of studying these manuals. Some of the personnel you train, however, may need guidance in the use of Rate Training Manuals. Although there is no single "best" way to study a training manual, the following suggestions have helped many people:

1. Study the naval requirements and the professional qualifications for your rate before you study the training manual, and refer to the "quals" frequently as you study. Remember,

you are studying the training manual primarily to meet these "quals."

2. Set up a regular study plan. If possible, schedule your studying for a time of day when you will not have too many interruptions or distractions.

3. Before you being to study any part of the training manual intensively, get acquainted with the entire manual. Read the preface and the table of contents. Check through the index. Thumb through the manual without any particular plan, look at the illustrations, and read bits here and there as you see things that interest you.

4. Look at the training manual in more detail, to see how it is organized. Look at the table of contents again. Then, chapter by chapter, read the introduction, the headings, and the subheadings to give you a clear picture of the scope and content of the manual.

5. When you have a general idea of what is in the training manual and how it is organized, fill in the details by intensive study. In each study period, try to cover a complete unit–it may be a chapter, a section of a chapter, or a subsection. The amount of material you can cover at one time will vary. If you know the subject well, or if the material is easy, you can cover quite a lot at one time. Difficult or unfamiliar material will require more study time.

6. In studying each unit, write down questions as they occur to you. Many people find it helps to make a written outline of the unit as they study, or at least to write down the most important ideas.

7. As you study, relate the information in the training manual to the job you are now doing. When you read about a process, a skill, or a situation, ask yourself: Does this information tie in with past experinece? Is this something new and different? How does this information relate to the qualifications for advancement?

8. When you have finished studying a unit, take time out to see what you have learned. Look back over your notes and questions. Maybe some of your questions have been answered, but perhaps you still have some that are not answered. Without referring to the training manual, write down the main ideas you have learned from studying this unit. Do not just quote the manual. If you cannot give these ideas in your own words, chances are that you have not really mastered the information.

9. Use Nonresident Career Courses whenever you can. The Nonresident Career Courses are based on Rate Training Manuals or other appropriate texts. As mentioned before, a mandatory Rate Training Manual can be completed by passing a Nonresident Career Course based on the training manual. You will probably find it helps to take other Nonresident Career Courses, as well as those based on mandatory training manuals. Taking a Nonresident Career Course helps you to master the information given in the training manual, and also gives you an idea of how much you have learned.

INCREASED RESPONSIBILITIES

When you assumed the duties of a PO3, you began to accept a certain amount of responsibility for the work of others. With each advancement you accept an increasing responsibility in military matters and in matters relating to the professional work of your rate. When you advance to PO1 or CPO, you will find a noticeable increase in your responsibilities for leadership, supervision, training, working with others, and keeping up with new developments.

As your responsibilities increase, your ability to communicate clearly and effectively must also increase. The simplest and most direct means of communication is a common language. Use correct language in speaking and in writing. Remember that the basic purpose of all communication is understanding. To lead, supervise, and train others, you must be able to speak and write so that others can understand exactly what you mean.

Leadership and Supervision

As a PO1 or CPO, you will be regarded as a leader and supervisor. Both officers and enlisted personnel will expect you to translate the general orders given by officers into detailed, practical, on-the-job language that can be understood and followed by relatively inexperienced personnel. In dealing with your juniors, it is up to you to see that they perform their jobs correctly. At the same time, you must be able to explain to officers any important problems or needs of enlisted personnel. In all military and professional matters, your responsibilities will extend both upward and downward.

Along with your increased responsibilities, you will also have increased authority. Officers and petty officers have POSITIONAL authority–that is, their authority over others lies in their positions. If your CO is relieved, for example, he no longer has the degree of authority over you that he had while he was your CO, although he still retains the military authority that all seniors have have over subordinates. As a PO1, you will have some degree of positional authority; as a CPO, you will have even more. When exercising your authority, remember that it is positional–it is the rate you have, rather than the person you are, that gives you this authority.

A Petty Officer conscientiously and proudly exercises his authority to carry out the responsibilities he is given. He takes a personal interest in the success of both sides of the chain of command. . .authority and responsibility. For it is true that the Petty Officer who does not seek out and accept responsibility loses his authority, and then the responsibility he thinks he deserves. He must be sure, by his example and by his instruction, that the Petty Officers under him also accept responsibility.

For information on the practical application of leadership and supervision, study *Military Requirements for Petty Officer 1 & C,* NAVEDTRA 10057 (Series).

As you study this material containing leadership traits, keep in mind that probably none of our most successful leaders possesed all of these traits to a maximum degree, but a weakness in some traits was more than compensated for by strength in others. Critical self-evaluation will enable you to realize the traits in which you are strong and to capitalize on them. At the same time you must constantly strive to improve on the traits in which you are weak.

Your success as a leader will be decided, for the most part, by your achievements in inspiring others to learn and perform. This is best accomplished by personal example. Inspiring others to learn and setting a personal example are just two leadership traits covered in more detail in Chapter II in the *Division Officer's Guide of the United States Naval Institute.* Other principles of leadership and administration are discussed eloquently in Chapters IV, V, VI, and X of the same source.

Training

Navy training is changing in several ways. For example, it is becoming more and more individualized, a change brought about by the introduction of sources of programmed instruction courses and a few audio/visual courses. These types of courses permit a student to choose his medium of instruction and to proceed at his own pace (self-paced instruction). Then, too, all future instructional material must be job-related and "system designed"; that is, it must teach the trainee to do a task; and it must follow a specific course, including defining the need, planning, developing, and evaluating the course. Thus, all elements required for a complete course will be included in each unit. Training for men and women in many ratings will be planned from the time they enter the Navy until they retire. The objective is to use all the training given and eliminate the "overtraining" prevalent in the past. Many, if not all, "A" schools will be reduced in length; some other schools will be eliminated. Consequently, more training must be done aboard the ship or station. To expedite onboard training, a great many "onboard training packages" will be produced. Many of these will be multimedia packages.

As a PO1 or CPO, you will have regular and continuing responsibilities for training others. Even if you are lucky enough to have a group of subordinates who are all highly skilled and well trained, you will still find that training is necessary. For example, you will always be responsible for training lower-rated personnel for advancement. Also, some of your best workers may be transferred; and inexperienced or poorly trained personnel may be assigned to you. A particular job may call for skills that none of your personnel have. These and similar problems require that you be a training specialist–one who can conduct formal and informal training programs to qualify personnel for advancement, and one who can train individuals and groups in the effective execution of assigned tasks.

In using this training manual, study the information from two points of view. First, what do you yourself need to learn from it? And second, how would you go about teaching this information to others?

Training goes on all the time. Every time a person does a particular piece of work, some learning is taking place. As a supervisor and as a training expert, one of your biggest jobs is to see that your personnel learn the RIGHT things about each job so that they will not form bad work habits. An error that is repeated a few times is well on its way to becoming a bad habit. You will have to learn the difference between oversupervising and not supervising enough. No one can do his best work with a supervisor constantly over him. On the other hand, you can rarely turn an entire job over to an inexperienced person and expect him to do it correctly without any help or supervision.

In training lower-rated personnel, emphasize learning and using correct terminology. A command of the technical languages of your occupational field (rating) enables you to receive and convey information accurately and to exchange ideas with others. A person who does not understand the precise meaning of terms used with the work of his rating is definitely at a disadvantage when he tries to read official publications relating to his work. He is also at a disadvantage when he takes the examinations for advancement. To train others in the correct use of technical terms, you will need to be very careful in your own use of words. Use correct terminology and insist that personnel you are supervising use it too.

You will find the *Record of Practical Factors,* NAVEDTRA 1414/1, a useful guide in planning and carrying out training programs. From this record, you can tell which practical factors have been checked off and which ones have not yet been done. Use this information to plan a training program that will fit the needs of the personnel you are training.

On-the-job training is usually controlled through daily and weekly work assignments. When you are working on a tight schedule, you will generally want to assign each person to the part of the job that you know he can do best. In the long run, however, you will gain more by assigning personnel to a variety of jobs so that each person can acquire broader experience. By giving people a chance to do carefully supervised work in areas in which they are relatively inexperienced, you will increase the range of skills of each person and thus improve the flexibility of your working group.

Working With Others

As you advance to PO1 or CPO, you will find that many of your plans and decisions affect a large number of people, some of whom are not even in your own occupational field (rating). It becomes increasingly important, therefore, for you to understand the duties and the responsibilities of personnel in other ratings. Every petty officer in the Navy is a technical specialist in his own field. Learn as much as you can about the work of others, and plan your own work so that it will fit into the overall mission of the organization.

Keeping Up With New Developments

Practically everything in the Navy–policies, procedures, publications, equipment, systems–is subject to change and development. As a PO1 or CPO, you must keep yourself informed about changes and new developments that affect you or your work in any way.

Some changes will be called directly to your attention, but others will be harder to find. Try to develop a special kind of alertness for new information. When you hear about anything new in the Navy, find out whether there is anyway in which it might affect the work of your rating. If so, find out more about it.

SOURCES OF INFORMATION

As a PO1 or CPO, you must go to references for accurate, authoritative, up-to-date information on all subjects related to the naval and professional requirements for advancement.

Publications mentioned in this chapter are subject to change or revision from time to time–some at regular intervals, others as the need arises. When using any publication that is subject to revision, make sure that you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been made.

The educational services officer will have the most up-to-date information and training manuals applicable to your rating.

In addition to training manuals and publications, training films furnish a valuable source of supplementary information. Films that may help are listed in the *U.S. Navy Film Catalog,* NAVAIR 10-1-777.

ADVANCEMENT OPPORTUNITIES FOR PETTY OFFICERS

Making chief is not the end of the advancement line. Advancement to Senior Chief (E-8), Master Chief (E-9), Warrant Officer, and Commissioned Officer are among the opportunities available to qualified petty officers. These special paths of advancement are open to personnel who have demonstrated outstanding professional ability, the highest order of leadership and military responsibility, and unquestionable moral integrity.

ADVANCEMENT TO SENIOR AND MASTER CHIEF

Chief petty officers may qualify for the advanced grades of Senior and Master Chief. These advanced grades provide for substantial increases in pay, together with increased responsibilities and additional prestige. The requirements for advancement to Senior and Master Chief are subject to change but, in general, include a certain length of time in grade, a certain length of time in the naval service, a recommendation by the commanding officer, and a sufficiently high mark on the Navy-wide examination. The final selection for Senior and Master Chief is made by a regularly convened selection board.

Examination Subjects

Qualifications for advancement to Senior Chief Petty Officer and Master Chief Petty Officer have been developed and published in the *Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards,* NAVPERS 18068 (Series). They officially establish minimum military and professional qualifications for Senior and Master Chief Petty Officers.

Bibliography for Advancement Study, NAVEDTRA 10052 (Series) lists references which may be used to study for both military and professional requirements.

The satisfactory completion of the Nonresident Career Course titled *Military Requirements for Senior and Master Chief Petty Officers,* NAVEDTRA 91209, is required of all personnel advancing to E-8 and E-9.

ADVANCEMENT TO WARRANT AND COMMISSIONED OFFICER

The Warrant Officer program provides opportunity for advancement to warrant rank for E-6 and above enlisted personnel. E-6s, to be eligible, must have passed an E-7 rating exam prior to selection.

The LDO program provides a path of advancement from warrant officer to commissioned officer. LDOs are limited, as are warrants, in their duty, to the broad technical fields associated with their former rating.

If interested in becoming a warrant or commissioned officer, ask your educational services officer for the latest requirements that apply to your case.

CHAPTER 2

WORK CENTER SUPERVISION AND ADMINISTRATION

As a Chief or First Class Aviation Structural Mechanic H you may be assigned duties as the safety and survival equipment work center supervisor. A work center is a functional area to which maintenance personnel are assigned; therefore, a division, branch, or shop may be referred to as a work center. The term "work center" came into existence with the establishment of the 3-M System.

The responsibility of supervision and administration of a work center is a many-sided and enduring task. Some of the techniques will have been learned through past experience while still others will have to be learned during the actual supervision and administration of the work center or by self-study courses and technical publications. The intent of this chapter is to acquaint the new supervisor with some of the more important aspects of supervision and administration.

SUPERVISOR REQUIREMENTS

The AMH in a supervisory position sets in motion the plans, schedules, and policies of his superiors. His primary concern is seeing that the job gets done, rather than performing the work himself.

To accomplish this end, the supervisor must know his men, assign them work within their capabilities, direct their efforts, and assume responsibility for seeing that each job is done correctly.

The supervisor's objectives are to operate with maximum efficiency and safety, to operate with minimum expense and waste, and to operate as much as possible free from interruption and difficulty. These three objectives are amplified in *Military Requirements for Petty Officer 1 and C*, NAVEDTRA 10057 (Series).

It is important that an AM assigned supervisory duties keep in mind the importance of his new assignment to himself personally. It affords him the opportunity to gain practical experience for future promotions. His duties cannot be approached in a haphazard manner. To make right decisions, the supervisor must be knowledgeable, possess integrity, and utilize common sense. He should employ the principles of good leadership in carrying out his assignment. The information provided in *Principles and Problems of Naval Leadership*, NAVEDTRA 15924 (Series), will prove invaluable to the new supervisor until he has gained more experience.

KNOWLEDGE

Effective supervision of a work center requires a competent degree of knowledge concerning all areas of aircraft maintenance that could affect the work center. The senior petty officer must keep abreast of new ideas and be aware of the variety of directives and publications that regulate his actions. He must be knowledgeable of the factors that make him a maintenance manager, of programs that affect his work area, of his rating, and of the weapon system being supported.

Maintenance Management

Maintenance may be defined as any function related to retaining equipment/material in, or restoring it to, a serviceable condition by servicing, repair, modification, modernization, overhaul, test, inspection, etc. The term maintenance has a general meaning and therefore will rarely be used by itself in manuals, instructions, etc. It will almost always be followed or preceded by another word which conveys a more specific meaning.

Management is also a general term to denote central executive direction and control of a work effort by an individual or group of individuals who are provided appropriate resources and assigned to accomplish a function.

The term maintenance management as it applies to production divisions, branches, and work centers is defined as the process of planning, organizing, staffing, directing, and controlling of an organization's industrial resources necessary in the physical performance of equipment maintenance. The goals of maintenance management are the effective and economical support of all equipment required to achieve the operational objectives of the Secretary of the Navy and the Deparmtent of Defense.

Maintenance management as it pertains to the Naval Aviation Maintenance Program and the Maintenance Data Collection Subsystem is based on the principle of management by exception. It means simply that actions or incidents which vary markedly from established standards or norms are singled out as exceptions from the whole for special management attention. For example, if certain models of aircraft or equipment consistently fail to attain established material readiness standards, those models would be singled out for special study and appropriate corrective action. If certain aircraft systems or equipment chronically fail and/or consume abnormal numbers of maintenance manhours or replacement parts, this exception would receive special attention. Work centers which consistently fail to meet production schedules or which consistently require personnel to perform overtime work might also be singled out for special attention. The principle of management by exception is not new and is particularly adaptable to aviation maintenance through the use of modern machine data processing equipment.

Supervisors at all levels concerned with maintenance must consciously and intelligently apply this principle in order to most effectively use their resources in men, money, and materials.

The principles of planning, organizing, staffing, directing, and controlling must be understood and implemented at all levels of command if maintenance is to be accomplished in an orderly manner. The supervisor who coordinates his work center's activites and communicates, both externally and within the activity, provides the catalyst which ensures that effective application of these basic principles provide a smooth functioning maintenance organization.

The *Naval Aviation Maintenance Program (NAMP),* OPNAV Instruction 4790.2 (Series), outlines command, administrative, and management relationships and establishes policies for the assignment of aviation maintenance tasks. As defined in this instruction, the work center supervisor is responsible for the following actions:

1. Ensuring the accomplishment of all assigned work.
2. Ensuring maximum utilization of personnel and facilities.
3. Making recommendations concerning work center repair capabilities and facility requirements.
4. Causing all work to be inspected as required.
5. Initiating of material requirements to support the workload.
6. Screening of all source documents, work requests, and associated paperwork to ensure accuracy, completeness, and timeliness of submission.
7. Keeping maintenance control informed of work status.
8. Reviewing of daily manhour (when applicable) and maintenance data reports for accuracy and submission of necessary corrections.
9. Ensuring that the maintenance department training program is properly supported within the work center.

The supervisor who endeavors to become thoroughly familiar with the contents of the *Naval Aviation Maintenance Program Manual,* volumes 1-4, will be better equipped to handle the administrative affairs of the work center. By the time most petty officers reach the E-5 level, they should be totally familiar with the variety of source documents associated with aircraft maintenance. Use of these documents is covered in appropriate chapters of volume II and III of OPNAVINST 4790.2 (Series).

Special Programs

The senior AM will by necessity become involved in the variety of special programs that directly or indirectly affect the supervision of his work center. OPNAV Instruction 4790.2 (Series) provides ampiifying information on selected maintenance programs such as the following:

1. Component repair.
2. Foreign object damage (FOD) prevention program.
3. Corrosion control and preservation.
4. Hydraulic fluid surveillance.
5. NavAirSysCom calibration program.
6. Zero defects.

Separate chapters provide in-depth information concerning Quality Assurance, Unsatisfactory Material/Condition (UR) Reporting System, Planned Maintenance System, etc.

Rating

The supervisor who has had varied experience in all aspects of his rating is a definite asset to any command. A complete knowledge on one's rating is not easily achieved. All too often, personnel put in the required training courses and rely on the information retained from the Rate Training Manual to get them by. Study of the latest editions of these manuals, and the additional reference material listed in NAVEDTRA 10052 will assist in the never-ending attempt to stay current. When advancement in rating qualifications change, the alert petty officer notes these changes and strives to correct any knowledge deficiencies that might exist. Curiosity regarding activity correspondence, changes and bulletins changes to maintenance publications and other maintenance directives, as well as changes to other sources of information which affect the supervisor's work center and/or rating can result in increased ability and confidence.

Weapon System Being Supported

The number of aircraft accidents, ground accidents, and incidents involving maintenance errors has increased steadily for the past several fiscal years. As the number of errors increased, the most often repeated errors continued to be the same from year to year. Some of the errors cause little or no damage and consequently have not been appropriately advertised. Many maintenance errors can be attributed to failure of the supervsior to properly perform his duties.

A knowledge of the weapon system being supported is a must requirement. The training lectures prepared for use in training personnel within the work center should be a valuable source of information regarding the weapon system. Study of the appropriate volumes of the *Maintenance Instructions Manual* that affect the AMH and completion of courses on the weapons system provided by the NAMTRADETs will better equip the supervisor to make decisions regarding maintenance of the systems. Use of the MIM when performing maintenance applies to both the worker and the supervisor. The complexity of many of today's aircraft systems requires that step-by-step procedures be followed for accomplishing removal, installation, repair, operational testing, etc. It is impossible to commit these step-by-step procedures to memory. Personnel who are unfamiliar with a task that is assigned should readily admit their lack of proper training rather than attempt the task with questionable results. It is not uncommon for a supervisor to find that a subordinate has greater knowledge of a particular system than the supervisor. If he has been to one of the NAMTRADET's courses on that particular system and/or has considerable experience, it is entirely conceivable. However, the supervisor must make it a habit to verify any doubtful information and correct any knowledge deficiencies on his part, or he may lose some of the respect necessary to maintain control of his men. This is not to imply that he should be distrustful of his men. Sometimes subordinates feel that information passed on to them by others is correct without verifying it in the MIM. In summary, it is better to admit when you do not know something and then follow through by doing something about it immediately.

SUPERVISION AND LEADERSHIP

The experienced petty officer will soon learn that supervision and leadership are very closely related. The supervisor's role requires that he be a leader, a man of common sense, and a man who earns the respect of others. Many decisions are difficult to make. To be effective in his decision making, the supervisor assembles pertinent facts, policies, and procedures; develops a course of action and evaluates possible alternatives; selects the best course of action; and initiates the required action. When necessary he consults his own superior prior to taking action. Every supervisor must face problems squarely and make timely and sound decisions. The supervisor who dodges his responsibilities will soon find his control of subordinates slipping away, discipline deteriorating, dissatisfaction with his supervision increasing, and effectiveness of the organization suffering.

The supervisor who establishes and maintains a spirit of cooperation within his work center and in the everyday dealings with other work centers and maintenance control will find his job is much easier. Aircraft readiness is the common purpose of the maintenance organization, and all ratings should share a common interest in achieving that purpose. A willingness by each individual to submerge his personal interests in favor of getting the job done is a necessary prerequisite to cooperation. If the supervisor's requests are reasonable, made well in advance (when possible), are understood, and provide all the necessary information, his requests will generally induce cooperative action. If cooperation is lacking, check the facts to find out why. If subordinates are at fault, they can be told directly and in a firm manner, taking into consideration the basic principles of good leadership.

The supervisor's duties involve planning, direction, and control. Careful planning is an essential ingredient to effective supervision and minimizes other types of supervisory efforts when carefully executed. Time and effort invested in the process of careful planning are rarely wasted. They can result in job simplification and increased efficiency.

The effective supervisor initiates the planning process by identifying each specific job to be done by his men. With a routine clearly established, he can spend his time on the exceptions that may arise. He knows the capacities, interests, weaknesses, and potentials of his men. Knowing each man's level of technical skill, motivation, ambitions, and personality characteristics will enable the supervisor to (1) assign the right man to the right job, (2) identify the training needed by each man to do a better job, and (3) establish the standard at which each man can be expected to perform.

Once action has been initiated, the supervisor provides direction. This function of supervision is like that of a "foreman." He sees that work is started and knows what is going on at all times. This does not mean that he must always be physically present while the job is being done. Subordinates should be trained to assume responsibility for the job in the absence of the supervisor so that no man is indispensable, including the supervisor. The supervisor should, however, be available when his men are working, and they should know how to contact him. The supervisor should always be present when his men are assigned new tasks, when they have trouble getting a job done, or when other circumstances dictate the necessity for his presence. He must be careful not to oversupervise lest he destroy the initiative of his workers and subordinate supervisors. He receives suggestions and reactions from his subordinates and acts as necessary on them, giving credit when and where it is due. Recognition of each man as an individual is required.

Control of a job refers to the function of checking to see that the job is done as planned—a comparing of performance with plans. Deviations may reflect poor planning. However, procedures should exist whereby changes in plans that could result in improved performance can be implemented to minimize repetition of faulty performance.

The supervisor will be challenged to allocate sufficient time to be expended on planning, direction, and control. A spirit of firmness, fairness, cooperation, decisiveness, harmony, and mutual respect while seeing that the job is done will rarely go unrewarded.

Communications

The area of communications as related to supervision and leadership is singled out here because of its importance. Almost without exception, problem areas regardless of their nature can be attributed to the lack of proper communications. Men like to be kept informed about all the things that affect them. Keeping them informed will improve their morale and generally make them more responsive to the needs of the command. The supervisor can improve morale by keeping his men as well informed as possible concerning need-to-know and nice-to-know information that could affect them, as long as it is not classified.

Communications is a two-way process. The supervisor must be able to convey his ideas, orders, etc., and pass on information, either orally or in writing, in such a manner that it will be clearly understood. He must also be willing to listen to and try to understand the ideas of others. Subjectivity (that is, looking at things only from a personal viewpoint, because of your position, rating, pay grade, or any other reason) will hinder communications. Bias and limited knowledge can limit a supervisor's ability to be objective, and by recognizing this fact he can listen more objectively.

Ridicule, sarcasm, vulgarity, etc. have no place in good communications. The supervisor who must get loud and resort to such language to get his point across or the job done needs to realize how adversely such action affects his own feelings of importance and respect. When it becomes necessary to orally reprimand a subordinate, do it in private, keeping in mind that he is an individual and as a petty officer he must have the respect of the men under him. If a supervisor reprimands a man in public, both lose respect and are less effective in getting the job done.

Professionalism

It is the responsibility of all senior petty officers to instill a spirit of professionalism in their subordinates. Aircraft maintenance is a reasonably complicated profession that leaves little room for error. The maintenance man who gives it less than his undivided attention presents a potential hazard. Of primary importance are the ethical attitudes and considerations involved in performing each maintenance task, the unspoken but carefully adhered to codes governing each man's actions.

The responsible petty officer sets the example he wishes others to follow, doing the right thing in carrying out each assignment, including (and especially so) when no one is watching. Undiluted professionalism means that there is no room for ethical lapses or occasional breaches of integrity. The worker who even once shortcuts established procedures, does not follow maintenance manual instructions, sacrifices quality for speed, or performs any other action which could produce a negative judgment towards him lacks the professional integrity demanded in aviation maintenance. The supervisor who condones such action is equally guilty of a less than professional attitude and the results that such actions could cause.

There is no substitute for thorough knowledge of your aircraft, your job, and the procedures associated therewith. Correct maintenance procedures and thorough quality assurance will almost always produce professional results. Aviation safety demands pure, undiluted professionalism from all personnel involved in maintenance.

WORK SIMPLIFICATION

Work simplification is a common sense, systematic method of identifying and analyzing work problems, developing solutions, and installing improvements. In order to achieve maximum efficiency each supervisor must do his part to improve the work situation and achieve maximum manpower utilization. This implies that the greatest possible use of all resources available be made in order to help accomplish an activity's mission. Work simplification is a tool which can be utilized effectively in the accomplishment of this goal. Work simplification might be considered as human ingenuity applied to the work situation. It is the organized use of common sense and creative thinking in the solution of work problems.

If all men had believed that there could be no better way of doing things, we might still be throwing rocks at game for our food and traveling from place to place on foot. Progress in these fields was not made in a single step but in a series of improvements. These changes occurred slowly over the centuries, growing out of a multitude of small improvements.

The supervisor who lives day to day, satisfied that what he did yesterday is good enough for tomorrow, will, in most cases, leave his job no better from having held it. He leaves nothing significant for other personnel who follow him in his job, and he becomes lost in the shuffle of men who are content with merely living and dying.

The majority of improvements in our world did not come by accident; rather, they came as a result of man's ingenuity, growing out of his sense of imperfection and his constant search for improvement. When an improvement is made no matter how small, it marks its discoverer as a person of imagination with a real and active interest in his work.

The supervisor who believes in and practices work simplification procedures can look with pride upon his contributions or those of people who work with him. This means that the supervisor should never cease to search for improvement and must encourage his workers to try to improve jobs over which he has control.

The supervisor should always watch for areas where work can be simplified. Work simplification pays immediate dividends by increasing both production quality and quantity. It allows the supervisor to meet work schedules more easily and reduces waste by producing with less effort, increases savings in time and manhours, and thus reduces cost of operation. Work methods improvement aids in establishing standard procedures. These standard procedures aid in training both old and new workers, since most workers are easier to train, and learning is much easier if standard practices are used.

An example of work simplification that is widely used in maintenance activities is a reports tickler file. The tickler file contains information on each report concerning the kind of report required, form or format to be used, due date, address of the office or command to which it is sent, etc. Although the governing directive should be consulted when preparing a report, a properly used reports tickler file simplifies and assists in the preparation and timely submission of required reports.

Work simplification should be considered when arranging the shop equipment (intermediate maintenance) in the work center. Equipment should be located so that ample room is available to accommodate its use. When possible, equipment should be arranged in a logical manner so that jobs requiring the utilization of several items of equipment can be performed in a manner similar to that found in assembly line operations. In a like manner, visual information display boards and/or status boards utilized to control maintenance should be located where they can be easily viewed and kept current without disrupting other personnel.

It is true that with good leadership personnel can be encouraged to work to the limit of their physical endurance but unless their efforts are used wisely, the most critical resource–manpower–is being wasted. In the final analysis, it is not how hard personnel work but how much quality work is accomplished that matters. Therefore, to help achieve maximum results with minimum expenditure of human effort, the supervisor should always strive to use established work simplification techniques.

Work simplification permits continuous evaluation by analyzing existing methods and procedures with a view toward improving them. There is always a better way of performing a task by using streamlined methods, improved tools, better working conditions, or shorter procedures. However, these better methods are not always apparent. Work simplification should be directed at all work situations where physical effort is expended.

Techniques

There are many techniques for improving work methods. For the most part, these techniques are adaptable to any work center or production control as well as the whole activity. Five of the principal techniques which have been successfully applied to work operations are discussed briefly in the following paragraphs. All of these techniques require the construction, completion, and use of lists, charts, flow diagrams, etc., in order to study and analyze specific areas.

WORK DISTRIBUTION ANALYSIS.–Work distribution analysis is a technique used to analyze objectively the division of work in an organization. In order to obtain the most effective distribution of work, it is necessary for the supervisor to have an overall view of the organization and its operations. The supervisor must clearly understand the work that is being done and be able to see the relationship between the overall operation and the individual work units as well as the contribution that each person makes to the work of the whole organization.

Distribution of work is an important factor in efficient use of manpower. Time and effort are saved if related duties are performed by the same person. Thoughtful matching of assignments and qualifications is important so that personnel are not struggling with work that is too hard for them or wasting their time on tasks that might be performed by a less skilled person. Another consideration is distribution of workload to avoid inequalities, since these result in bottlenecks and other inefficiencies.

Work distribution analysis requires that Task List be completed for each person whose work is being studied. This list contains, in simple statements, tasks the worker performs regularly and the average number of hours spent on each task per week. Next, a Function List is prepared which lists each function performed by the work center. Each task reported on the Task List must be related to a specific function. A Work Distribution Chart is prepared from the data collected on the Task List and Function List. This chart presents the work performed in the existing organization under current operating conditions. The chart is then studied and analyzed to find answers to questions such as the following:

1. What functions take the most time?
2. Is there misdirected effort?
3. Are skills being used properly?
4. Are personnel doing too many unrelated tasks?
5. Are tasks spread too thinly?
6. Is work distributed evenly?

A careful study and analysis of the work distribution chart should assist in achieving the following results:

1. Elimination of unnecessary tasks.
2. Reduction of time spent on relatively unimportant functions.
3. Elimination of duplication and overlapping of work.
4. Better balance of workloads.
5. Combination of related tasks.
6. Realistic estimate of personnel needs.
7. Better utilization of skills.
8. Reallocation of misassigned personnel.

WORK COUNT ANALYSIS.–Work count analysis supplements the work distribution analysis and is a technique for determining the volume of work in terms of measurable units. Information obtained by counting or measuring the work provides a basis for improving methods and procedures, adjusting work assignments, evaluating performance, and eliminating bottlenecks. Such information is useful in assigning and scheduling work to ensure that the workload is equitably distributed among all personnel.

Items of work counted should be definite and comparable. Items counted should also be representative of work usually performed. Only those should be counted that clarify methods employed. Counting may take place where the work comes into production control, where a decision is made or action is taken, where a process is completed, or where long storage occurs.

Work count information can be used to accomplish the following:

1. Establish how long it takes to do a given piece of work.
2. Indicate whether the volume of a certain piece of work is sufficient to warrant specialization.
3. Show whether work is distributed evenly among workers.
4. Point out bottlenecks where work piles up.
5. Indicate whether the work center is adequately manned, overmanned, or undermanned.
6. Stimulate interest of personnel by providing comparisons of one person's work with that of another or with his own record during a different counting period.

FLOW PROCESS ANALYSIS.–Flow process analysis is a technique for analyzing flow and sequence of operations. The purpose of this analysis is to reduce time and distances in a process by eliminating, combining, and changing the sequence of steps in the flow of work.

The principal tool of this technique is the construction of a flow process chart which provides a clear and detailed picture of the flow of work. Recording each step in a procedure helps to identify duplication of effort, backtracking, and other obstacles to the smooth, efficient flow of work.

MOTION ANALYSIS.–Motion analysis is a technique for making maximum use of physical motions. It is a method of studying the motions of individuals in performing their various tasks.

Work distribution and flow process analyses are directed toward improving the division and flow of work. Motion analysis deals with how an individual performs his tasks. It seeks to learn whether the workers are doing their work with minimum fatigue, loss of time, and waste of effort. Improvements are effected by rearrangement of materials and work area and by proper use of equipment.

The simplest way of gathering data for motion analysis is for the supervisor to watch his personnel at work and note useless motions. Motion analysis should result in the elimination of wasteful motions and consequent loss of work time, reduction of fatigue by lessening the amount of physical effort required to complete a task, and increased efficiency of personnel.

LAYOUT ANALYSIS.–Layout analysis is a procedure designed to lead to better utilization of space, personnel, and equipment. A study of the layout of a working area can provide useful information for improving the work of individuals, distribution of the workload, and flow of work from one person to another. Its purpose is to determine what space is needed for the operations to be performed and how the available space may be used most effectively. Besides shortening and simplifying motions, it should produce working conditions that are as comfortable and personnally satisfactory to the workers as possible consistent with efficient and economical operation.

The layout chart is the principal tool of this type of analysis. This chart consists of a floor plan of the work space, showing doors, windows, electrical outlets, etc. All features that restrict usable space should be included. Items of equipment (test bench, hose burst machine, bending equipment, etc.) should be added and the anticipated flow of work indicated.

The flow principles should be kept in mind when studying a work center layout chart:

1. Equipment getting the most use should be located in the most accessible areas.
2. Layout should provide for safe use of equipment.
3. Arrangement of equipment and facilities should allow for effective supervision.
4. Arrangement of equipment should accommodate the necessary flow of personnel utilizing the work area.
5. Maintenance publications should be conveniently accessible to those who use them.
6. Working space allocations should be consistent with working conditions.

INSTALLATION OF IMPROVEMENTS.--Briefly speaking, work simplification means improving methods of doing work or finding a better way. Improved methods usually involve eliminating unnecessary parts of the job, combining and rearranging other parts of the job, and simplifying the necessary parts of the job. By improving methods personnel are able to do better work, with less effort, in less time, without hurrying, with greater safety, and with lower cost. The pattern for achieving the benefits of work simplification is as follows:

1. Select the job to be improved.
2. Break down the job in detail.
3. Question the job and each detail of the job.
4. Develop the new method.
5. Apply and install the new method.

The fact that changes are recommended as a result of a work simplification study does not always mean that these changes will or can be made immediately. There are several reasons why a change that many regard as an improvement may be slow in being adopted.

Most changes will draw objections from a certain number of persons. There are two general types of reasons for these objections. First, many people regard a recommended change as a criticism of the way they have been doing their work and therefore resent it. Most of this type of objection can be avoided if those who will be affected by the change can participate in some degree in the analysis so that the whole enterprise becomes a group activity. If this is not possible, at least a clear explanation should be made regarding reason for the change. Emphasis should be on future advantages rather than criticism of old methods. Secondly, most people have a natural dislike to changing established work habits. If advantages of the new method are clearly explained, this resistance lessens considerably.

Before making any changes it is well to consider carefully all likely effects, for sometimes unforeseen effects may cancel out the beneficial aspects of the change. It is important, for instance, when new equipment or facilities are contemplated, to be sure that advantages of the new installations will outweigh cost. Indirect effects of change upon other equipment or conditions should also be considered.

Effects upon interorganization relationships should also be taken into account. If work procedures are speeded up in one phase of an operation only to create a bottleneck in another, there will be little or no improvement.

PLANNING WORK CENTER ARRANGEMENT

The average Chief or First Class Aviation Structural Mechanic H may never have the opportunity of planning the layout of a work center in a new facility. In almost every case, the new supervisor will take charge of an already functioning division or else, when his squadron or unit moves to a new base, he and his crew will usually be assigned to spaces already basically equipped. In either case, a reevaluation of the work center's layout is indicated. The reevaluation of the layout should include finding out from the applicable allowance lists if the equipment allowances have been changed in any way. There is no use relocating equipments which involve rewiring or plumbing work if improved replacement models are authorized and available.

PURPOSE OF THE WORK CENTER

The work centers have been established to meet the needs and demands of their specific maintenance tasks involved within the activity to ensure and aid in carrying out the overall mission of the activity.

A basic consideration in planning a work center layout is its purpose. When more than one space is available, the supervisor must decide which space would be better suited or advantageous to his work center's work. Thus, the general function of the work center must be considered in the allocation of spaces and equipment. This decision should be based on factors of safety, economy, functional compatibility, and convenience.

ARRANGEMENT

Following the determination of which work center is to occupy which space or area within a space comes the arrangement of furniture and equipment.

The arrangement of the work center furnishing should be made on the basis of utility rather than appearance. Moving an item of equipment into an out-of-the-way corner may greatly improve the appearance of the work center but at the same time reduce the efficiency of personnel using the equipment and may possibly create a safety hazard. A good rule to follow is to locate equipment where it can be safely used by the greatest number of people with a minimum of effort in the least amount of time.

Work tables and benches should be positioned with respect to fixed equipment so that the equipment most often used is most quickly and easily reached. Electrical and compressed air outlets should be readily available to the workbenches. Needless delays are caused by having to rig unnecessarily long connections from poorly located outlets.

Near workbenches where specific and intricate maintenance functions are performed, consideration should be given to installing special lighting such as explosion-proof, vaporproof, or interference-free type lighting. Under certain conditions, special lighting may also include floodlights for outside work areas and in hangars when improved lighting is required.

Utilization of paint in various colors to emphasize portions of intricate machinery for safety and reflective purposes is known as dynamic painting. Painting in this category should not be utilized for normal building maintenance.

A system of stowing tools must be devised. An intelligent system cannot be set up without first determining from allowance lists what tools will be required for satisfactory operation of the work center. The place for all tools should be marked or otherwise specified, and everything not being used should be kept in that place.

The layout should make provisions for a bulletin board upon which may be posted safety posters, maintenance posters, instructions and notices, plans-of-the-day, and such other information as is appropriate from time to time. The bulletin board should be located in a prominent place in the work center, preferably near the entrance where everyone assigned will have to pass at some time or another during the day. Material on the bulletin board should be changed frequently, expired notices promptly removed, the current plan-of-the-day posted early, and other posters and material rotated periodically. If the same material is presented in the same format every day, it will not be long before the men begin to ignore the bulletin board and purposes for having it are defeated. New arrangements are noticed and interest is stimulated with variety.

When aviation organizational level maintenance activities are moved aboard ship, their working conditions and accommodations are drastically affected. The ingenuity of the supervisor will be required to produce a workable arrangement within very limited spaces. Stowage racks for toolboxes and other work center equipment should be located to accommodate their frequency of use. Some equipment used at less frequent intervals may have to be stowed in voids. An inventory listing of such items, showing their specific location, will be necessary. Security of material stowed in voids, toolboxes, and other equipment will require more attention than when ashore. Gear not properly stowed and afforded appropriate security has a habit of disappearing and during rough sea states, can be hazardous to personnel and/or other equipment.

Much of the work done aboard ship will have to be done under less than ideal conditions. Confined spaces, reduced lighting during nighttime flight operations, hazardous conditions on the flight and hangar decks, problems associated with respotting of aircraft to accommodate maintenance, and a variety of conditions peculiar to ship operations will require modification of procedures used ashore. The supervisor should ensure that spaces are utilized to their fullest extent.

Since most organizational level maintenance is "on aircraft" type maintenance, the limited space of the work center should present only a minor problem concerning the stowage of gear and some personnel congestion during periods when personnel are awaiting work. Consideration of the factors previously discussed under "Work Simplification," could result in a smoother transition from shore to shipboard facilities and vice versa.

PROCURING AND CUSTODY OF MATERIAL

The work center supervisor is responsible for ordering aircraft maintenance spare parts and material, tools, and other equipment necessary for the accomplishment of assigned maintenance tasks. Necessarily related to this responsibility are requirements for controlling the use of consumable materials, maintaining and accounting for tools and material held on a custody signature basis, and, when required, the preparation and submission of evaluation reports.

AIRCRAFT PARTS

Aircraft parts are generally ordered for two reasons, the first being replacement for parts which are removed from service on a scheduled basis. These are usually parts which by their failure may cause disastrous consequences. The other general need for aircraft parts results from the failure, damage, or unsatisfactory operation of an aircraft component. As can be seen, parts in the former category may be ordered in advance so they can be on hand when required, but the latter cateogry may not, as their usage is generally unforeseen. In either event, the ordering procedure is the same.

NOTE: Prior to ordering a replacement for a failed part, the supervisor should always consider his responsibility and capability to effect the repair of the old part. If this capability exits (and is permissible) at his level and the repair is accomplished, it will prevent the expenditure of a great amount of time, trouble, and money required to process such material through higher levels of maintenance.

In a more or less predictable length of time consistent with the priority, the part will be delivered to the shop. Prior to opening the package or breaking the preservation in any manner, the National Stock Number and any other identifying data on the package should be double checked against the shop order file to ensure that they match. Upon depackaging, another check similar to the foregoing should be made to positively identify the part.

If either inspection reveals any inconsistencies of identification data, it may be that the supply office has substituted an interchangeable item. If so, the substitute item should be checked in the Illustrated Parts Breakdown, Section B Allowance List, or the Interchangeability List for ASO and NavAir Cognizance Repairable Assemblies. Interchangeability is discussed in greater detail in chapter 3. If possible, an actual comparison with the old part should be made prior to installation as a further check for suitability.

TOOLS

Ordering of tools is accomplished in much the same manner as ordering of aircraft spare parts. The need for a tool should develop during a periodic tool inventory in order to eliminate a work delay which might develop if a required tool was first discovered missing or damaged during the progress of a job.

Unlike aircraft parts, which should not be stocked in the shops, the Section G Allowance Lists provide for each activity performing organizational maintenance to have on hand a certain quantity of tools. The applicable allowance lists should be cross-checked with a current tool inventory and any deficiencies made up as soon as possible. In some cases, it may be determined that some tools on the allowance lists are not needed or that the allowed quantity exceeds actual requirements. In such cases, those tools should not be ordered just to have them collect dust on the toolroom shelves. In addition, excess tools serve to complicate the periodic inventories.

Special tools peculiar to a specific weapon system are listed on the activity's Individual Material Readiness Listing (IMRL), discussed in chapter 3 of this manual.

GROUND SUPPORT EQUIPMENT

Items of ground support equipment (GSE) used for servicing and maintaining aeronautical equipment consists of equipment furnished as organizational property and equipment furnished on subcustody from the supporting activity. The Individual Material Readiness Listing (IMRL) discussed in chapter 3 of this manual, provides an authorized allowance listing for GSE which may be procured or obtained on subcustody by the supported activity.

Work centers charged with the custody of GSE must ensure that proper care is exercised in its daily maintenance, upkeep, and operation. Daily Maintenance Requirements Cards are available for use in maintaining most larger items of support equipment. Items on subcustody from the supporting activity are normally recalled to the supporting AIMD for periodic maintenance inspections.

The supporting activity licenses qualified operators and provides GSE training, in addition to that which may be given as part of the work center's training syllabus. All operators of ground support equipment must be qualified and licensed. The license should be carried at all times when operating GSE.

Status code A ground support equipment is that equipment in the possession of an organization or intermediate maintenance activity and being used in support of assigned missions. Reporting custodians are accountable for each item of GSE in status code A and must report data on its utilization (hours/cycles/starts). Prepunched/preprinted GSE cards are available for utilization reporting. Utilization is reported on the last day of each reporting period.

GSE on subcustody to squadrons or other activities remains the responsibility of the reporting custodian. Personnel designated as being responsible for GSE, within the activity having subcustody, must compile utilization on an appropriate GSE card and forward it to the reporting custodian on the last day of the reporting period. Reporting procedures are provided in detail in volume III of the *Naval Aviation Maintenance Program,* OPNAV Instruction 4790.2 (Series).

INVENTORY AND RECORDS

When the work center is first set up and the initial allowance of tools and equipment is drawn, inventory cards should be made up on each item. These cards should include the name of the item, quantity, manufacturer, model, stock number, date of acquisition, cost, and dates and nature of repairs and replacement parts.

Some items should be kept in the work center toolroom or special cabinet; others placed in individual toolboxes and issued to the workers. A toolbox inventory record should be prepared in duplicate with the original filed in the work center files and the duplicate copy placed in the toolbox, preferably in an oil and grease resistant envelope.

While each toolbox should be adequately stocked, it should not contain tools in excess of actual requirements. Maintenance personnel must utilize some method of tool accountability following each maintenance action to prevent tools being left adrift. Tools should be etched or marked in some other manner that will identify them to a specific work center and toolbox. This acts as a deterent to leaving tools adrift and provides the additional benefit of cutting down on the amount of tool pilferage.

A monthly inventory should be conducted beginning with the toolboxes and ending with the toolroom count. The periodic inventory should be more than just an item count. Since each item is sighted, it provides an opportunity to ascertain if the tools in actual use are being maintained in good repair. If they show evidence of damage or improper use, appropriate corrective action should be taken. The men should be encouraged to make good use of delay time by tool maintenance and equipment servicing.

COST CONSCIOUSNESS

The Navy Cost Reduction Program, NAVSO P 2486, strives to create an attitude of total cost consciousness and to encourage the development and implementation of cost reducing actions. Maintenance supervisors as well as their subordinates can play a definite role in reducing costs. Areas where costs can be reduced should be identified and action taken through the chain of command. Recognition to the individual responsible for any cost reduction actions will serve to stimulate the cost reduction program.

Personnel involved in procurement of materials and equipment and those charged with custody of such items should realize that the overall costs for defense materials are tremendous. Costs of weapons systems, associated test equipment/support equipment, and spare parts necessary to support the weapon system during its expected service life have increased steadily to the point where improved management is necessary. Attention must be given to such areas as personnel error, waste of materials and resources, utilization of personnel, accident prevention, etc.

Improved work habits, elimination of unnecessary maintenance tasks, improvements to test equipment, consolidation of functions, greater use of resources, and increased capability for repair of specific items at the lowest level of maintenance are but a few areas that could be evaluated as a means of reducing costs at the working level. Supervisors should be alert to ways of bringing about such improvements and should encourage and assist their personnel in submitting factual beneficial suggestions for consideration and subsequent dissemination.

Materials belonging to the Navy are not procured for the personal use of the individual, yet thousands of dollars are lost annually due to poor control of material resources. Proper security of pilferable items will materially reduce costs. Ordering only that material which is actually needed rather than that which "might" be needed is another area that generally could receive attention. The ways of reducing costs are limited only by the supervisor's imagination and ingenuity. Waste, whether it is of manpower, money, or material, costs the taxpayer and therefore affects almost everyone.

EVALUATION REPORTS

The maintenance of today's high-performance aircraft requires more and more special tools, shop equipment, and ground-handling equipment. Most of this special equipment is designed and manufactured by private contractors. As a result, frequent requests are made by the manufacturer for field activities to evaluate this equipment before final approval is given on a procurement contract or changes are made to the appropirate allowance list. This procedure is approved and encouraged, but a standard procedure for conducting performance evaluations is necessary.

According to current instructions, the manufacturer's request must be approved by the type commander and cognizant COMFAIR before it can be accepted by a field activity for evaluation.

Upon approval, the designated activity should conduct a thorough evaluation of the tools or equipment provided by the manufacturer. NOTE: Failure to do so could result in the purchase of faulty and/or inadequate tools or equipment, thereby causing injury to personnel and/or damage to aircraft and other equipment.

After completion, the activity conducting the evaluation provides the manufactuier, via the COMFAIR and type commander, with a report of the evaluation findings, citing any defects or recommendations for improvement. The report should include the manufacturers' name, name of the product, model number, size, and/or capacity of the product evaluated, and the specific function for which the product may have been used.

TECHNICAL DATA

Technical data is provided for guiding naval personnel in training, operations, calibration, repair, storage, and shipment of weapon systems and related components within the Naval Establishment. This technical data is available in numerous forms and is an important element of the logistics support necessary for the insurance of fleet readiness and equipment availability. Personnel training, operation, and maintenance of today's sophisticated, high-performance weapons sytems demand the development and dissemination of accurate, clear, and concise technical information. Investigation proves that a technician's ability to support and maintain modern equipment is directly related to the quality of the documentation and the training program. In accordance with this requirement, NAVAIR has established a policy and management structure for control and production of fleet support technical data.

Technical data is recorded information used to define a design and to produce, support, maintain, or operate items of defense material. This data may be recorded graphic or pictorial delineations in media such as technical manuals, drawings, or photographs; text in specifications, related performance, or design type documents; and machine forms such as punched cards, magnetic tape, or computer memory printouts that may be retained in computer memory.

The NAVAIRSYSCOM furnishes aircraft maintenance activities with technical data necessary for the operation and maintenance of weapons systems and related equipment. Technical information and instructions are disseminated in the form of manuals and letter type material. By proper use of these publications, all aircraft and other aeronautical equipment can be operated and maintained efficiently and uniformly throughout the Navy.

From the foregoing it can be readily seen that maintenance activities require large quantities of technical data for the proper operation and maintenance of aeronautic equipment. The technical library operated by the activity's quality assurance division provides a central point for the procurement and proper dissemination of this technical data. It is the senior petty officer's responsibility to ensure that this technical data is utilized in the accomplishment of all maintenance efforts. In this regard, his awareness of technical data and his ability to procure, maintain, and utilize such data, will have a direct bearing on his value to the command and the manner in which he performs his duties whether as a crewmember, crew leader, or work center supervisor.

TYPES OF TECHNICAL DATA

Technical data is presented in varied forms; however, data available to fleet and repair activities falls into three major categories–technical manuals, technical directives, and engineering drawings and associated data.

1. Technical Manuals. To attain a satisfactory state of readiness, technical manuals are developed, published, and distributed concurrently with hardware. Periodic changes and revisions are issued as necessary to ensure that manuals continually reflect equipment configuration and current operational and support concepts and procedures. Technical manuals released under the authority of COMNAVAIRSYSCOM are considered the only authorized source of the information provided and the instructions contained therein are mandatory. NOTE: NAVAIR is currently developing the MIARS (Maintenance Information Automated Retrieval System) program which will convert many existing and all new technical manuals to a microfilm format. Manual users will be provided microfilm reader-printer equipment in the near future for the purpose of viewing microfilmed data, and when required, print-out copies of selected manual pages. Certain manuals (NATOPS, Check Lists, Maintenance Requirement Cards, etc.) will be issued in a dual format; printed volumes for primary users and microfilm for library and staff reference use.

2. Technical Directives. For rapid documentation of weapons systems or equipment change information, for citing of special inspection requirements, or for clarifying or emphasizing operational or maintenance parameters, NAVAIR issues information through the technical directive system.

3. Engineering Drawings and Associated Data. Engineering drawings and reference documents made by the designers of weapon

systems and equipment are procured from those designers and distributed to depot-level maintenance activities for use in maintenance and repair, for making parts not stocked in the supply system, for emergency fabrication, for engineering analysis and investigation, and for in-house redesign. The technical manuals system, the spart parts provisioning system, and the entire logistic support system assume that copies of engineering drawings will be available at depot-level activities. They are normally made available in microform. NAVAIRINST 5600.14 and 5600.15 govern in-service maintenance of drawings and requisitioning of drawings by field activities.

A complete technical data package as stated above, is not required by each operating and support activity for effective logistic performance. Aviation activities, station maintenance divisions, and other non-industrial units are normally provided all required technical data in the form of technical manuals and technical directives. Only industrial activities are normally provided engineering data in addition to manuals and directives.

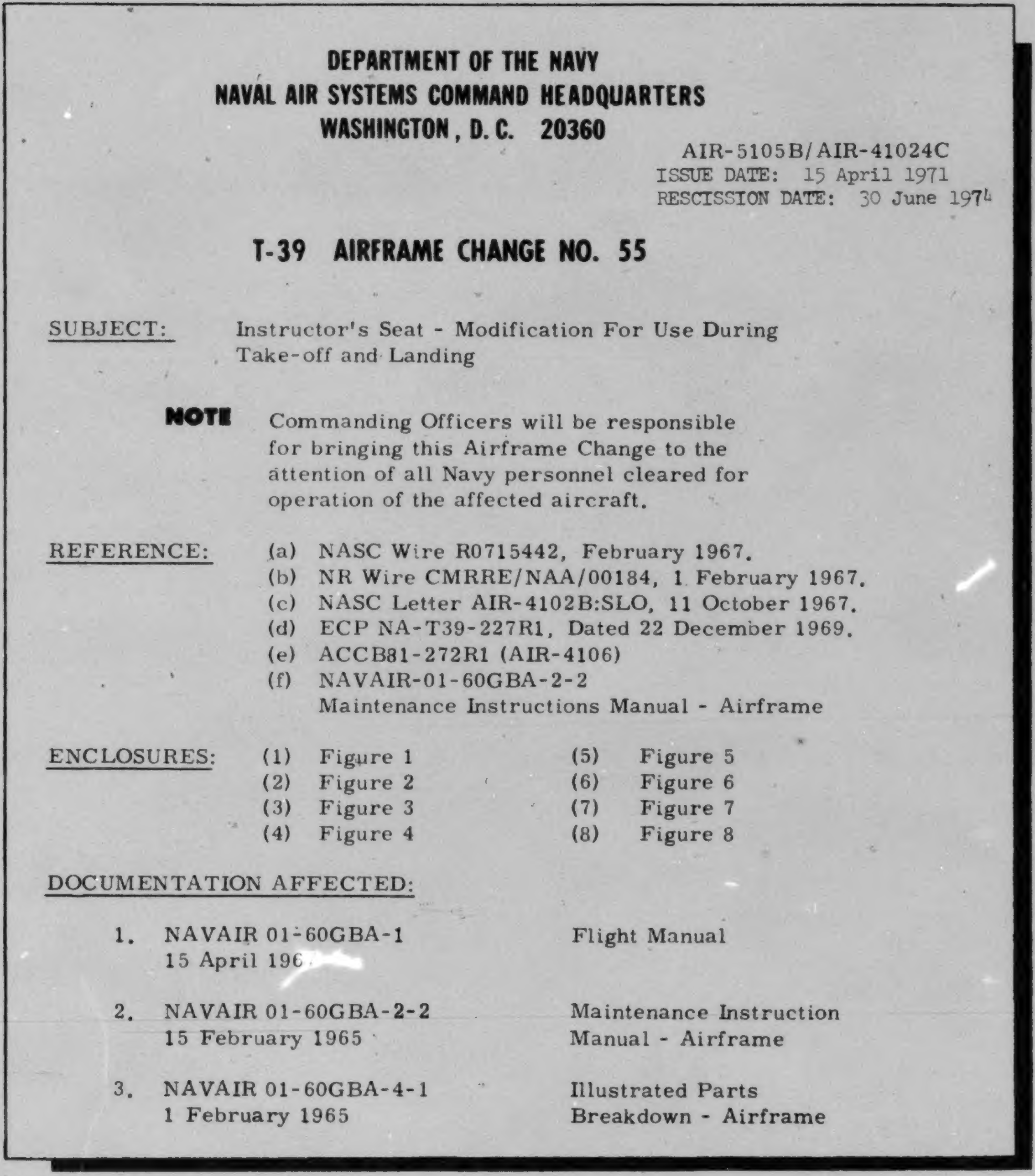
Data is prepared for support of the five major areas of coverage defined as follows:

1. Operations. Technical manual data is prepared describing the operation of major weapons systems or equipment. In the case of aircraft, it describes the aircraft, its installed systems, handling and servicing requirements, and operational limitations, etc.
2. Maintenance. Technical manual data, specialized test tapes, diagnostic information, and engineering data are designed to provide general and specific instructions required for performance of organizational, intermediate, and depot levels of maintenance and repair.
3. Training. Technical manuals are provided for support of operational and maintenance training.
4. Configuration Modification. Data necessary for alteration or modification of systems or equipment is distributed to using activities through the technical directive system. Concurrent changes to affected manuals are prepared and released through the manual distribution system to reflect the maintenance requirement for all system configuration.
5. Supply Support. Coordinated action between the NAVAIR, ASO, and SPCC provides supply documents such as allowance lists and initial outfittings lists. Illustrated parts breakdown manuals are prepared and distributed for specific systems and equipment to enable identification and supply support of spare components and spare parts. PPB's (Provisioning Parts Breakdwons) and MEAR's (Maintenance Engineering Analysis Records) are also provided when required to support maintenance and/or technical logistics operations.

TECHNICAL DIRECTIVE SYSTEM

The Technical Directive (TD) System has been established for control and issue of all technical directives. This system standardizes the method of issuance for such directives and is the authorized means for directing the accomplishment and recording of modifications and one-time inspections to equipment procured by and for the NAVAIRSYSCOM. The TD system is an important element in the programs designed to maintain equipment in a configuration which provides the optimum conditions of safety, operation, and material readiness. This system encompasses two types of Technical Directives differentiated by their method of dissemination. These two types are Formal (letter type) and Interim (message type). In general terms, they are both considered as letter type technical directives. These directives contain instructions or information of a technical nature which cannot be satisfactorily disseminated by revisions or changes to technical manuals. This information (instructions) is disseminated in the form of Changes, or in the case of special circumstances, by Interim Changes or Bulletins.

A formal TD, figure 2-1 is a document issued as a Change, or an Amendment or Revision thereto, and promulgated by letter. Formal technical directives are used to direct the accomplishment and recording of modifications to weapons, weapons systems, support equipment, trainers, and related equipment and are comprised of changes and amendments and/or revisions thereto.



DEPARTMENT OF THE NAVY
NAVAL AIR SYSTEMS COMMAND HEADQUARTERS
WASHINGTON, D. C. 20360

AIR-5105B/AIR-41024C
ISSUE DATE: 15 April 1971
RESCISSION DATE: 30 June 1974

T-39 AIRFRAME CHANGE NO. 55

SUBJECT: Instructor's Seat - Modification For Use During Take-off and Landing

NOTE Commanding Officers will be responsible for bringing this Airframe Change to the attention of all Navy personnel cleared for operation of the affected aircraft.

REFERENCE:
(a) NASC Wire R0715442, February 1967.
(b) NR Wire CMRRE/NAA/00184, 1 February 1967.
(c) NASC Letter AIR-4102B:SLO, 11 October 1967.
(d) ECP NA-T39-227R1, Dated 22 December 1969.
(e) ACCB81-272R1 (AIR-4106)
(f) NAVAIR-01-60GBA-2-2
Maintenance Instructions Manual - Airframe

ENCLOSURES:
(1) Figure 1
(2) Figure 2
(3) Figure 3
(4) Figure 4
(5) Figure 5
(6) Figure 6
(7) Figure 7
(8) Figure 8

DOCUMENTATION AFFECTED:

1. NAVAIR 01-60GBA-1 15 April 196 — Flight Manual
2. NAVAIR 01-60GBA-2-2 15 February 1965 — Maintenance Instruction Manual - Airframe
3. NAVAIR 01-60GBA-4-1 1 February 1965 — Illustrated Parts Breakdown - Airframe

216.236

Figure 2-1.—Formal TD, Change.

A Change is a document containing instructions and information which directs the accomplishment and recording of a material change, a repositioning, a modification, or an alteration in the characteristics of the equipment to which it applies. A Change is issued to direct that parts be added, removed, or changed from the existing configuration or that parts or material be altered, relocated, or repositioned.

A Change may be issued in parts to accomplish distinct parts of a total directed action or to accomplish action on different configurations of affected equipment. A Change may also be issued for Record Purposes. A Record Purpose Change is a TD issued to provide documentation of a modification which has been completely incorporated by the contractor or in-house activity in all accepted equipment and which does not require retrofit or the modification of repairables in the Navy's possession.

An interim TD, figure 2-2 is a document issued as a Bulletin or a Change, or as an Amendment or Revision thereto, and promulgated by message to ensure expeditious dissemination. The interim TD is reserved for those instances requiring expeditious correction of an operational or safety condition which embodies risks calculated to be intolerable within the lead time of a formal directive or maintenance publication change. Interim Changes are superseded by a formal change directive which will have the same number as the interim directive. Interim Bulletin directives are not superseded by formal bulletins as was previously the case. The NAVSUP 2002, will still have many formal bulletins listed until they are eventually phased out.

An Amendment is a document comprised of information which clarifies, corrects, adds to, deletes from, makes minor changes in requirements to, or cancels an existing technical directive. It is only a supplement to the existing directive and not a complete directive in itself. A maximum of three Amendments may be applied to a TD, each remaining in effect until rescinded or superseded by a Revision. A requirement for further amendment action necessitates the issuance of a Revision.

A Revision is a completely new edition of an existing directive. It supersedes the original directive or revision and all existing amendments.

A Bulletin is an interim document comprised of instructions and information which directs an initial inspection to determine whether a given condition exists. It specifies what action is to be taken if a given condition is found or not found.

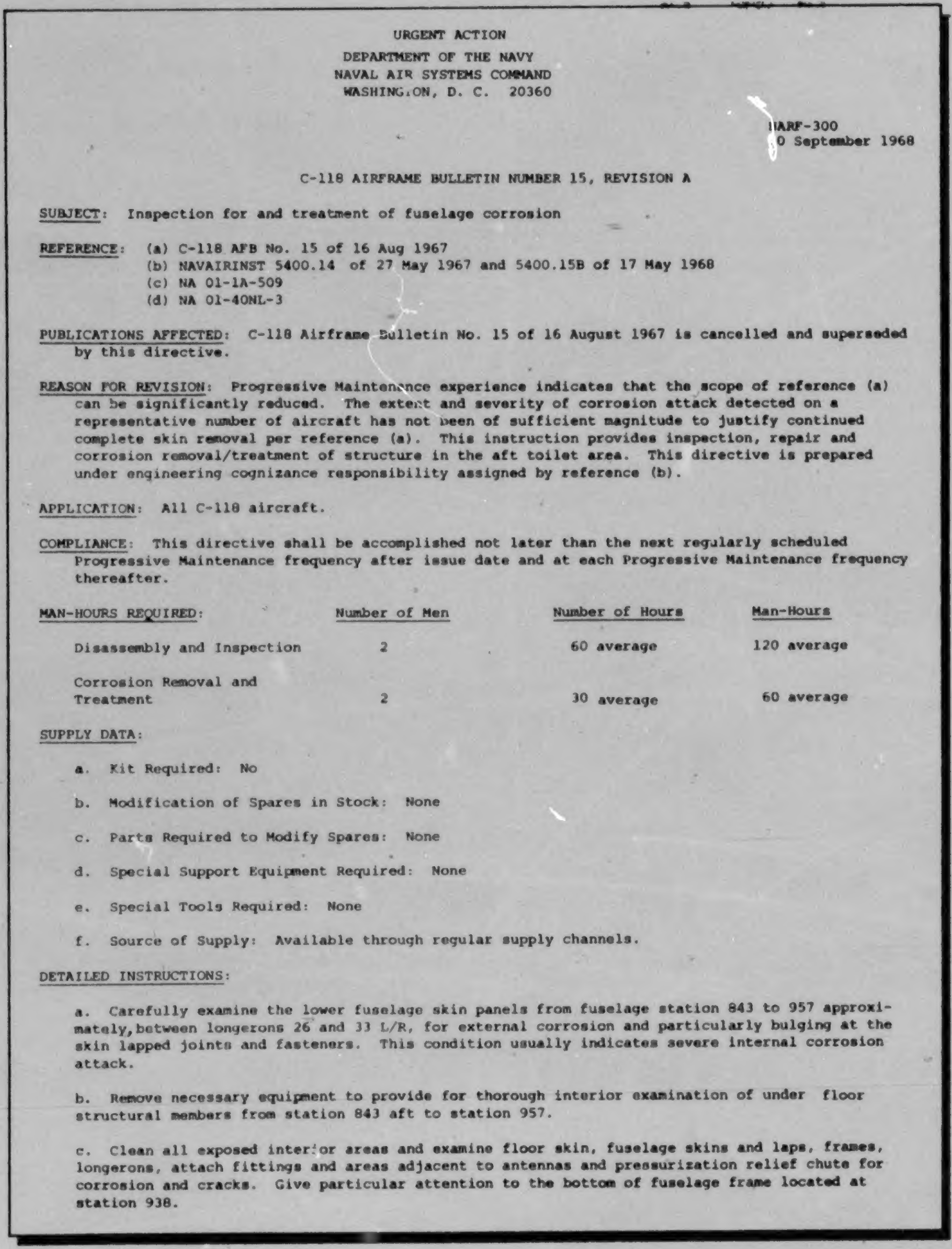
Interim bulletin directives are self-rescinding with rescission dates of 30 June or 31 December, whichever is appropriate for the case at hand. Rescission is the process by which TDs are removed from active files after all requirements have been incorporated. Final rescission action is directed in the TD Stock List, NAVSUP Publication 2002. All activities maintaining active technical libraries should maintain the TDs on file until they are deleted from the TD Stock List.

Cancellation of a technical directive is the process whereby the TD is removed from the active files when it is determined that a previously issued TD is not to be incorporated. Cancellation is directed by the issuance of an Amendment to the TD. The cancellation explicitly states the required configuration of each article initially specified for modification; for example, whether installed modifications are to remain installed or are to be removed, etc.

The title subject of a Change or Bulletin will be one of the following as appropriate:

Airframe
Powerplant
Avionics
Aviation Armament
Support Equipment
Propeller
Photographic
Airborne Weapon
Aircrew System
Accessory
Target Control System
Meteorological Equipment

Those of primary concern to the AMH will generally fall under the basic title of either Airframe, Accessory, or Support Equipment.



URGENT ACTION

DEPARTMENT OF THE NAVY
NAVAL AIR SYSTEMS COMMAND
WASHINGTON, D. C. 20360

NARF-300
0 September 1968

C-118 AIRFRAME BULLETIN NUMBER 15, REVISION A

SUBJECT: Inspection for and treatment of fuselage corrosion

REFERENCE:
(a) C-118 AFB No. 15 of 16 Aug 1967
(b) NAVAIRINST 5400.14 of 27 May 1967 and 5400.15B of 17 May 1968
(c) NA 01-1A-509
(d) NA 01-40NL-3

PUBLICATIONS AFFECTED: C-118 Airframe Bulletin No. 15 of 16 August 1967 is cancelled and superseded by this directive.

REASON FOR REVISION: Progressive Maintenance experience indicates that the scope of reference (a) can be significantly reduced. The extent and severity of corrosion attack detected on a representative number of aircraft has not been of sufficient magnitude to justify continued complete skin removal per reference (a). This instruction provides inspection, repair and corrosion removal/treatment of structure in the aft toilet area. This directive is prepared under engineering cognizance responsibility assigned by reference (b).

APPLICATION: All C-118 aircraft.

COMPLIANCE: This directive shall be accomplished not later than the next regularly scheduled Progressive Maintenance frequency after issue date and at each Progressive Maintenance frequency thereafter.

MAN-HOURS REQUIRED:	Number of Men	Number of Hours	Man-Hours
Disassembly and Inspection	2	60 average	120 average
Corrosion Removal and Treatment	2	30 average	60 average

SUPPLY DATA:

a. Kit Required: No

b. Modification of Spares in Stock: None

c. Parts Required to Modify Spares: None

d. Special Support Equipment Required: None

e. Special Tools Required: None

f. Source of Supply: Available through regular supply channels.

DETAILED INSTRUCTIONS:

a. Carefully examine the lower fuselage skin panels from fuselage station 843 to 957 approximately, between longerons 26 and 33 L/R, for external corrosion and particularly bulging at the skin lapped joints and fasteners. This condition usually indicates severe internal corrosion attack.

b. Remove necessary equipment to provide for thorough interior examination of under floor structural members from station 843 aft to station 957.

c. Clean all exposed interior areas and examine floor skin, fuselage skins and laps, frames, longerons, attach fittings and areas adjacent to antennas and pressurization relief chute for corrosion and cracks. Give particular attention to the bottom of fuselage frame located at station 938.

216.237

Figure 2-2.—Interim TD, Bulletin.

The "Airframe" title is utilized when the action required affects the structure or the installation of any equipment in an aircraft, trainer, drone, or target aircraft.

Airframe and Powerplant TDs are further subdivided into specific type/model breakouts, while other basic title TDs such as Accessory and Support Equipment Bulletins do not have breakouts.

EXAMPLES:

A-5 Airframe Change No. 63
J-79 Powerplant Change No. 27
Air Crew System Change No. 289
A-4 Interim Airframe Change No. 261
A-5 Interim Airframe Bulletin No. 111

If the technical directive involves safety of flight, the word "SAFETY" will appear immediately following the title and number.

The present numbering system is a consecutive numerical application regardless of the year of issue. For example, F-4 Airframe Change 204 would be the 204th Airframe Change that is applicable to the F-4 aircraft. This numbering system has been in effect for some time and most technical directives are cataloged under this system.

The numbers assigned to Changes and Bulletins are provided by the Technical Directives Control Center, which is located at the Naval Air Technical Services Facility (NATSF), Philadelphia. Changes or Bulletins that have been amended will have their basic number followed by the words "Amendment 1," "Amendment 2," etc. A revised directive will have the basic directive number followed with the words "Rev. A," "Rev. B," etc., as appropriate to denote the first, second, etc., revision to that basic directive. Directives may have only three (3) Amendments and then must be revised.

The Changes and Bulletins are automatically distributed to all concerned activities. All TDs are issued by NAVAIR or NAVAIRTECHSERFAC except in cases where the time delay in obtaining approval is unacceptable. In such cases the controlling custodians are authorized to issue interim TDs to preclude unacceptable risks to personnel or equipment. The Changes or Bulletins are generally based on Contractor Service Bulletins, URs, other letters of recommendation, or proposed modifications from field service activities.

Directive Categories

Technical directives are assigned a "compliance category" in accordance with the importance and urgency of accomplishing the work involved. A category of Immediate, Urgent, Routine or Record Purpose is assigned each technical directive.

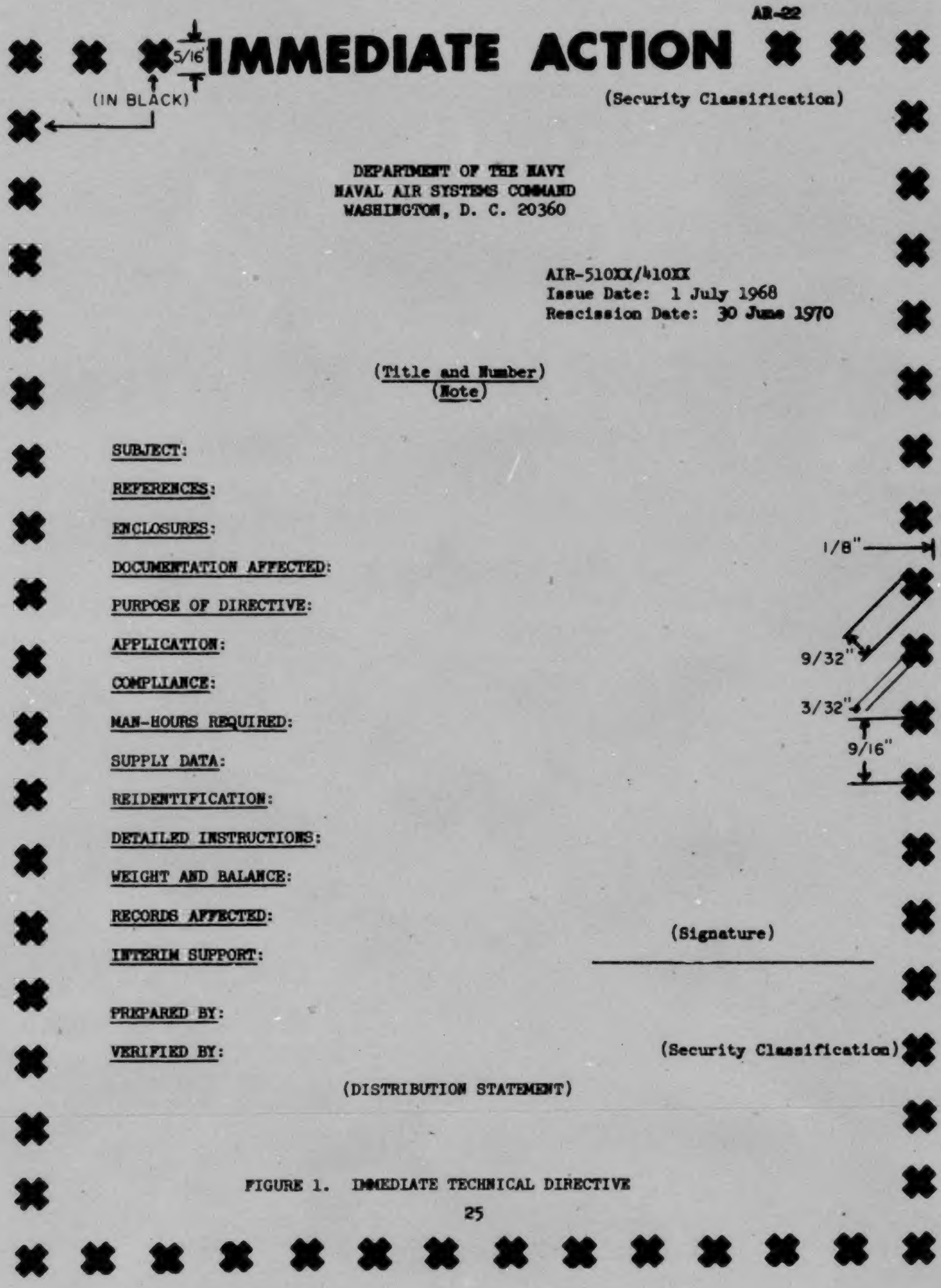
Immediate Action is assigned to directives which are issued to correct safety conditions, the uncorrected existence of which would probably result in fatal or serious injury to personnel, extensive damage, or destruction of property. These directives are identified by a border of black X's broken at the top center of the page by the words IMMEDIATE ACTION.

Urgent Action is assigned to directives which are used to correct safety conditions which, if uncorrected, could result in personnel injury or property damage. These directives are identified by the words URGENT ACTION at the top of the first page and a border of black diagonals around the cover page.

Routine Action directives are those concerned with equipment or procedural deficiencies of a material–mechanical, operational, or tactical in nature–the uncorrected existence of which could constitute a hazard. They are identified by the words ROUTINE ACTION printed in black at the top of the page.

Record Purpose is used when a modification has been completely incorporated by the contractor or in-house activity in all accepted equipment and when retrofit is not required of repairables in the Navy's possession. They are identified by the words RECORD PURPOSE printed in black capital letters at the top center of the first page.

The contents of technical directives and revisions thereto are presented in a standard format and written to conform with aeronautical requirements in a regular paragraph sequence. Listed below are the paragraphs in their required order, together with an explanation of their contents. Figure 2-3 illustrates this order.



AR-22

IMMEDIATE ACTION

(Security Classification)

DEPARTMENT OF THE NAVY
NAVAL AIR SYSTEMS COMMAND
WASHINGTON, D. C. 20360

AIR-510XX/410XX
Issue Date: 1 July 1968
Rescission Date: 30 June 1970

(Title and Number)
(Note)

SUBJECT:

REFERENCES:

ENCLOSURES:

DOCUMENTATION AFFECTED:

PURPOSE OF DIRECTIVE:

APPLICATION:

COMPLIANCE:

MAN-HOURS REQUIRED:

SUPPLY DATA:

REIDENTIFICATION:

DETAILED INSTRUCTIONS:

WEIGHT AND BALANCE:

RECORDS AFFECTED:

INTERIM SUPPORT:

(Signature)

PREPARED BY:

VERIFIED BY:

(Security Classification)

(DISTRIBUTION STATEMENT)

FIGURE 1. IMMEDIATE TECHNICAL DIRECTIVE

25

216.238

Figure 2-3.—Technical directive format.

1. Heading. The heading consists of the TD category and number, authorizing activity, cognizant codes, issue date, rescission date, and security requirements. A distribution statement which is actually a part of the heading information, is included on the last page of the directive.

2. Subject. This is a short topical statement, usually beginning with a noun to indicate the major component or system affected and ending with a brief statement of the action required.

3. References. All previous correspondence and publications relating to the directive are listed under this heading.

4. Enclosures. All enclosures which are appended are identified and listed.

5. Documentation Affected. This section lists all documents, such as manuals, existing technical directives, drawings, tapes, maintenance requirements cards, etc., which are affected by this directive.

6. Purpose of Directive. Each TD includes a concise explanation of its purpose with a summarization of the conditions which necessitated the action, such as potential hazards, failures, accidents, etc. If the TD is a revision, the reason for the original TD and the necessity for publishing the revision are both specified.

7. Application. This paragraph establishes the identity of all items affected. If the action required by the TD is dependent upon prior, concurrent, or subsequent incorporation of other TDs, a dependency statement is listed prior to other application data.

8. Compliance. This paragraph contains information indicating the time limit for performance of the work, the level of maintenance required to incorporate or accomplish the TD, and in some cases an incorporation schedule.

9. Manhours Required. This paragraph specifies the number of personnel and manhours by skill/specialty/rating and the total manhours required. This information is determined from experience or trial modifications whenever possible, otherwise estimates are given. Where more than one kit is included in the application, manhours are indicated for each kit. When an amendment is issued which affects manhours, only those manhours required to incorporate the amendments are reflected. Revisions reflect total manhours and also indicate the number of manhours required to incorporate the additional requirements of the revision for cases where the basic TD and existing amendments may have been previously incorporated.

10. Supply Data. The supply data section specifies the required kits, parts, materials, and special tools and/or equipment necessary to accomplish the TD. This data will include information relative to kit or kits required per aircraft, modification of spares in stock, disposition of removed parts, and the size, weight, and contents of each kit.

11. Reidentification. This paragraph specifies the requirements for marking or reidentifying the equipment or components which are modified by the incorporation of the TD.

12. Detailed Instructions. This section contains both written instructions and illustrations as necessary for the accomplishment of the TD.

13. Weight and Balance. If the TD affects weight and balance to a significant degree, a statement reflecting the effect will be provided in the format used in the original weight and balance manual for that equipment. In some cases the effect of weight and balance will be listed separately for each significant part.

14. Records Affected. This paragraph contains instructions specifying the action to be taken on all records affected by accomplishment of the TD.

15. Interim Support. If support is required to maintain the new configuration pending establishment of complete Navy support, such support is identified and described in this section. Data includes logistics elements, activity furnishing interim support, and the inclusive dates of interim support.

16. Signature. All TDs are signed by the Commanding Officer, NAVAIRTECHSERFAC, or his designated representative.

17. Prepared by. Each directive includes the name of the preparing organization and code.

18. Verified by. Each directive includes the name of the verifying organization and code.

Normally, the shop supervisor does not have to concern himself with the ordering of the change kits required for certain modifications. Standard aircraft maintenance organization procedures provide for Maintenance Control and Material Control to order such kits that are required through the use of the Technical Directives Compliance Form. Utilization of this form is covered in *Military Requirements for Petty Officer 3 & 2* and OPNAVINST 4790.2 (Series).

TECHNICAL MANUAL PROGRAM

The NavAir Technical Manual Program was established as the only official medium for disseminating technical information pertaining to the operation, installation, maintenance, and inspection of Navy aeronautical weapons systems, subsystems, and related support equipment.

Technical manuals are issued by the authority of the Chief of Naval Operations and released under the authority of the Commander, Naval Air Systems Command. Manuals and data pertaining to naval aviation are distributed through the Naval Air Technical Services Facility.

Technical manuals play an important role in achieving and maintaining system and equipment effectiveness and readiness. By proper utilization of technical manuals, systems and equipment can be operated and maintained uniformly throughout the Navy.

The variety of manual publications available to the AMH is necessary to understand operational theory, troubleshoot and service the systems, and maintain the systems and associated components. Use of the manuals on a continuing basis; that is, their use in performing each maintenance task, is mandatory. Past experience indicates that constant attention by supervisory personnel is necessary to ensure repetitive manual usage. Personnel assigned to perform the same task repeatedly can, if allowed, easily slip into the pattern of relying on memory rather than consult the specific manual that applies to performing the task. Needless to say, this is a dangerous, less than professional, and prohibited practice. Senior personnel must set the example by utilizing the manuals themselves and ensure that their subordinates do likewise.

Not every task or common maintenance procedure must or will be covered in detail in technical manuals. Application of common sense and good judgment regarding basic technical knowledge, complexity of tasks, and safety considerations are part of the governing criteria in determining the need for a manual or the inclusion of new material, changes, revisions, etc., to existing manuals.

If an error or collection of terminology in a maintenance manual provides a distorted meaning of instructive information or prevents adequate performance of functions required for mission accomplishment, it should be reported as a manual deficiency, utilizing an Unsatisfactory Material/Condition Report (UR). Minor discrepancies of a nontechnical nature are not considered deficiencies and will not be reported unless they change the meaning of instructive information and procedures. Criteria to be considered prior to reporting a deficiency, the category to be assigned the report based on the urgency of the action required, and other specific submission procedures are provided in the *Technical Manual, Naval Air Systems Command, Technical Manual Program,* NAVAIR 00-25-100, and OPNAV Instruction 4790.2 (Series). Failure to report known deficiencies could have serious consequences. It is each supervisor's responsibility to submit timely recommendation for change, addition, or deletion of information as necessary.

Chapter 2 of AMH 3 & 2, NAVEDTRA 10310-B provides a description of the contents and purpose of various types of manual publications of concern to AMH personnel, and knowledge of that material is presumed.

Updating Technical Manuals

The methods for assuring that technical manuals are maintained current to the extent necessary to maintain their validity or remove them from active status include issuing of Changes, Rapid Action Changes, Revisions, Supplements, and Appendices or by recission or replacement of a complete manual.

Revisions, Changes and Rapid Action Changes (RAC) are used to update manuals by replacing, adding or removing pages of the manual.

Changes

Changes are issued when only parts of the existing manual are affected. The change pages replace the correspondingly numbered pages. When the Change is a Formal Change, all replaced pages must be removed and discarded. If the Change contains additional data that cannot be included on the replacement page, additional pages are issued. The page numbers issued to additional pages are the preceding page number plus capital letter suffixes in consecutive order or page numbers continuing in numerical sequence, depending on the circumstances.

A Formal Change alters a portion of a manual already in existence and does not constitute a large enough change to warrant issuance of a Revision. The Formal Change replaces, adds, or deletes pages and/or illustrations and the change pages are prepared to be collated into the manual without disrupting the manual format and sequence. The Formal Change is issued to include new models of equipment or add new procedures and to change existing equipment and procedures which do not create an emergency situation.

Manuals consisting of eight pages or less and those which do not include a title page are replaced by a complete revision of the manual in lieu of change page insertions.

Rapid Action Changes

Rapid Action Changes (RACs) are manual changes used to expedite the dissemination and incorporation of essential and urgent operation and maintenance information to technical manuals. Utilizing an interim RAC, information impacting safety of flight, hazards to personnel, grounding of aircraft, mission capability, equipment damage, or maintenance capability will be disseminated via naval message and incorporated into the affected manuals immediately.

A Manual Change Page followup will then be required within 15 days of release of the message. Information of a less urgent nature is promulgated by printed Rapid Action Change Pages. This type RAC is subjected to printing within 30 days after problem resolution and is limited to 12 pages or less.

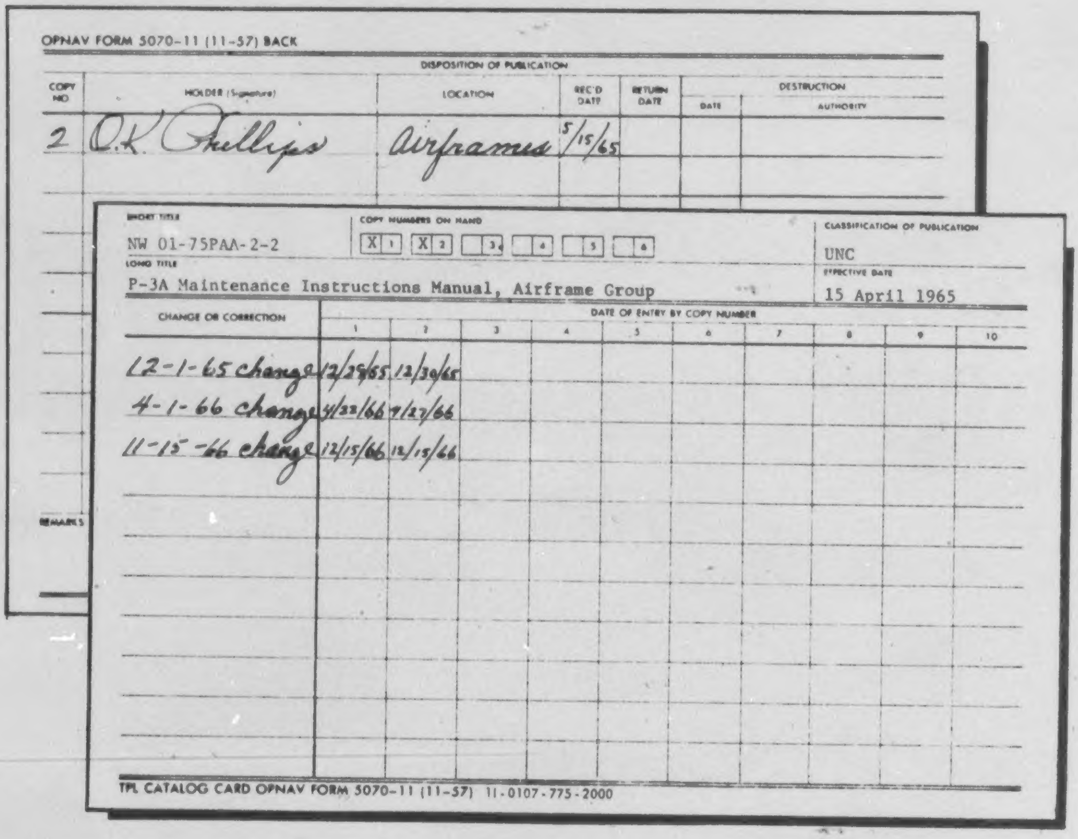
The RAC system has phased out the previous Interim Manual Change. However, it does not affect the procedures for issuing and incorporating Formal Changes. The RAC merely supplements the Formal Change procedures to provide for rapid issue of urgently required data that was previously held up by the procedures involved in complying with the normal change system.

Change Entry Certification

It is not feasible for every work center to have a copy of every publication that is used by the particular work center; however, they should have the publications most often used such as Maintenance Instruction Manuals, Illustrated Parts Breakdowns, and certain General Manuals. All publications held by the work center should be checked out (issued) from the activity's technical library, which functions as a part of the quality assurance division.

The technical library utilizes technical publications location catalog cards (TPL catalog cards), figure 2-4, to account for each publication held in the library as well as those issued to the various work centers. By using this system, the technical library can maintain reasonable control of all work center publications and applicable Revisions, Changes, etc., can be procured and issued as necessary to keep all publications current.

When Changes for a particular publication are received, technical library personnel check the location card and issue the Change to all holders of that publication, utilizing a Change Entry Certification Form (figure 2-5). When the Change has been incorporated, the certification portion of the form is completed by the holder and returned to the technical library. This provides a record that the Change has been incorporated in the applicable publication. Most technical library systems dictate a maximum



OPNAV FORM 5070-11 (11-57) BACK

DISPOSITION OF PUBLICATION

COPY NO	HOLDER (Signature)	LOCATION	REC'D DATE	RETURN DATE	DESTRUCTION	
					DATE	AUTHORITY
2	O.K. Phillips	Airframes	5/15/65			

REMARKS

SHORT TITLE: NW 01-75PAA-2-2

COPY NUMBERS ON HAND: ☒ 1 ☒ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

CLASSIFICATION OF PUBLICATION: UNC

LONG TITLE: P-3A Maintenance Instructions Manual, Airframe Group

EFFECTIVE DATE: 15 April 1965

CHANGE OR CORRECTION	DATE OF ENTRY BY COPY NUMBER									
	1	2	3	4	5	6	7	8	9	10
12-1-65 change	12/29/65	12/30/65								
4-1-66 change	4/22/66	4/27/66								
11-15-66 change	12/15/66	12/15/66								

TPL CATALOG CARD OPNAV FORM 5070-11 (11-57) 11-0107-775-2000

234.29

Figure 2-4.–TPL Catalog Card.

time allowed for incorporation of the Change to discourage "putting off" incorporation of Changes, which have presented a problem on more than one occasion. Publications that were not current have been used to perform maintenance tasks resulting in situations that are potential flight safety hazards.

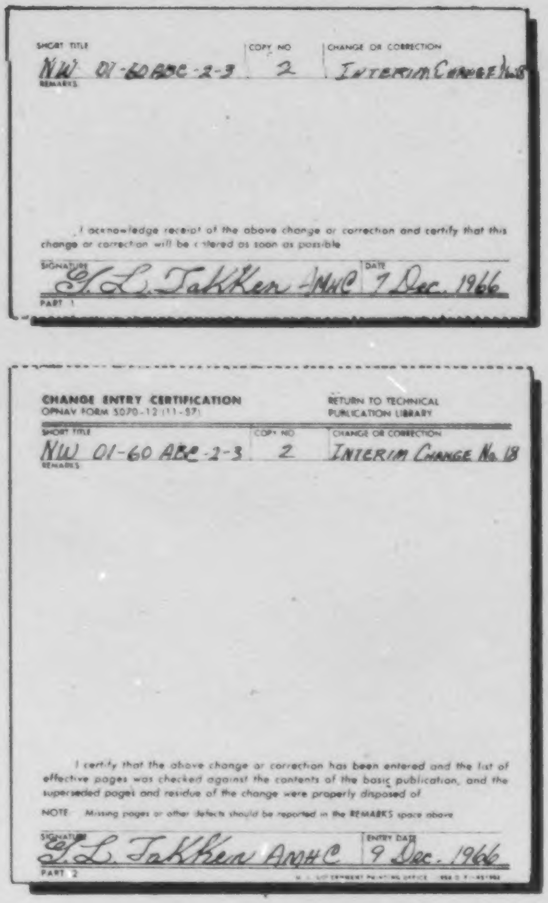
Quality Assurance is charged with the responsibility of making quarterly library audits of each work center's publications to ascertain that the publications are updated properly.

NOTE: That portion of the text affected by the current Change or Revision is normally indicated by a heavy vertical line in the outer margin of the page.

SUPPLEMENTS

Supplements are issued as separate manuals to augment existing manuals or change data when the use of change pages is not suitable or practical, and may be cumulative or noncumulative. Cumulative Supplements include all the data contained in Supplements previously issued and supersede the preceding Supplement. The Supplement will be sectioned in a manner appropriate to the manual which it supplements and will be identified by the same manual title and number as the basic manual with the word "Supplement" printed at the top of the title page.

Appendices are issued when it becomes necessary to include information in a manual



SHORT TITLE NW 01-60ABC-2-3	COPY NO 2	CHANGE OR CORRECTION INTERIM CHANGE No 18

REMARKS

I acknowledge receipt of the above change or correction and certify that this change or correction will be entered as soon as possible

SIGNATURE G. L. Takken AMHC	DATE 7 Dec. 1966

PART 1

CHANGE ENTRY CERTIFICATION
OPNAV FORM 5070-12 (11-57)

RETURN TO TECHNICAL
PUBLICATION LIBRARY

SHORT TITLE NW 01-60 ABC-2-3	COPY NO 2	CHANGE OR CORRECTION INTERIM CHANGE No. 18

REMARKS

I certify that the above change or correction has been entered and the list of effective pages was checked against the contents of the basic publication, and the superseded pages and residue of the change were properly disposed of

NOTE Missing pages or other defects should be reported in the REMARKS space above

SIGNATURE G. L. Takken AMHC	ENTRY DATE 9 Dec. 1966

PART 2

234.30

Figure 2-5.—Change Entry Certification Form.

that is not part of the normal sequence outlined in the contents, such as charts, tables, listing of codes, etc. Such material becomes an integral part of the affected manual.

DIRECTIVES ISSUANCE SYSTEM

Instructions and notices are the two main types of directives provided for in the Directives Issuance System which was designed for the purpose of providing a uniform plan of issuing and maintaining directives. Directives may establish policy, organization, methods, or procedures. They may require action to be taken or contain information affecting operations or administration. All Naval Air Systems Command level (and above) originated directives are distributed by the Navy Department Administrations Office, with certain exceptions. Each level of command below Naval Air Systems Command level has an administration office responsible for distributing that level of command directives to its units or addresses below them.

Instructions are those directives containing authority or information having continuing reference value, or requiring continuing action. An Instruction remains in effect until superseded or otherwise canceled by the originator or higher authority.

Notices are directives of a one-time or brief nature, which have a self-canceling provision, and which have the same force and effect as an Instruction. Usually, a Notice will remain in effect for less than 6 months, but is not permitted to remain in effect for longer than 1 year. Any requirement for continuing action contained in a Notice, such as the submission of a report, use of a form, or following a specified procedure, is considered to be canceled when the Notice is canceled, unless the requirement is incorporated into another suitable document.

Instructions and Notices are identified by originator and subject classification. There are 13 major subject classification groups. These major series groups are further subdivided by the use of the last three digits in the major series. The 13 major series groups consists of the following:

1000 Series. Military Personnel.
2000 Series. Communications.
3000 Series. Operations and Readiness.
4000 Series. Logistics.
5000 Series. General Administration and Management.
6000 Series. Medicine and Surgery.
7000 Series. Financial Management.
8000 Series. Ordnance Material.
9000 Series. Ships Design and Ships Material.
10000 Series. General Material.

11000 Series. Facilities and Activities Ashore.
12000 Series. Civilian Personnel.
13000 Series. Aeronautical and Astronautical Material.

These major subject groups are subdivided into primary, secondary, and sometimes tertiary breakdowns. Primary subjects are designated by the last 3 digits (the hundred group) of the code number, secondary subjects by the last 2 digits, and tertiary breakdown by the final digit. For example:

5000 General Administration and Management.
5200 Management Programs and Techniques.
5210 Office Methods and Paperwork.
5215 Issuance Systems.

Some of the smaller subject groups are not subdivided below the primary breakdown. Other larger subject groups are divided into many secondary and tertiary subjects, the extent depending upon the scope and complexity of the major subject.

The first Instruction issued on any of the subject group code numbers will be XXXX.1. For example, the first Instruction issued by NavAirSysCom on directive issuance is 5215.1. Subsequent Instructions issued on the same subject would be numbered in consecutive order; i.e. 5215.2, 5215.3, etc. When there is substantial change in an Instruction, it is rewritten, reissued, and carries the date of revision. Each revision is assigned the same subject classification number as the superseded Instruction, and is further identified by a suffix capital letter; the first revision being A, the second B, etc.–for example, 5215.2A.

When changes to instructions are not extensive, they are issued as page replacements or pen changes or a combination of both. Additional pages are also issued as a change. These changes are issued in the form of change transmittals. A change transmittal describes the nature of the change. It is prepared in directive format and is identified by the same number as the instruction which it changes plus the assigned change number. For example, the first change transmittal applicable to OPNAV Instruction 5442.2B would be identified as follows: OPNAVINST 5442.2B CH-1.

The AMH supervisor will normally be more concerned with records concerning the 4000, 5000, and the 13000 series of the 13 major subject groups. These series are further expanded as follows:

4000 Series–Logistics. This series covers subjects relating to the logistical support of the Navy and Marine Corps, including procurement, supply control, property redistribution and disposal, travel and transportation, maintenance, construction and conversion, production and mobilization planning, and foreign military assistance.

5000 Series–General Administration and Management. This series includes subjects relating to the administration, organization, and management of the Department of the Navy, including general personnel matters, security, external relations, law and legal matters, office services, and publication and printing matters.

13000 Series–Aeronautical and Astronautical Material. This series includes subjects relating to aeronautical and astronautical material such as parts, accessories, instruments, special devices, armament, aerological equipment, weapons systems, types of aircraft, and astronautic vehicles.

NOTE: Notices are not assigned consecutive numbers because of their one-time nature or brief duration. There may be several Notices bearing the same number, differentiated by date of promulgation and subject title.

Each command issues a 5215 directive semiannually which lists all directives by subject, subject number, revisions issued in the last 6 months, and those in effect.

Directives are filed by subject classification number, originator, and consecutive number.

The degree of security classification is indicated alphabetically on each confidential or secret directive, by prefixing the specified letter to the subject number; that is, "C" for confidential and "S" for secret. (Top secret material is excluded from issuance in the directives system.)

NOTE: In the past the procedure to indicate the degree of security classification was to prefix the subject number with zeros. One zero for confidential and two for secret. This prefix is no longer being assigned to new material; however, it remains in effect for those existing directives until superseded.

The issuance of unnecessary directives has been the subject of official concern on more than one occasion. Perhaps this is best expressed by the following quote from OPNAV Notice 5216 of 11 September 1963 (Reduction of Administrative Correspondence in the Operating Forces), which as directed to all ships and stations:

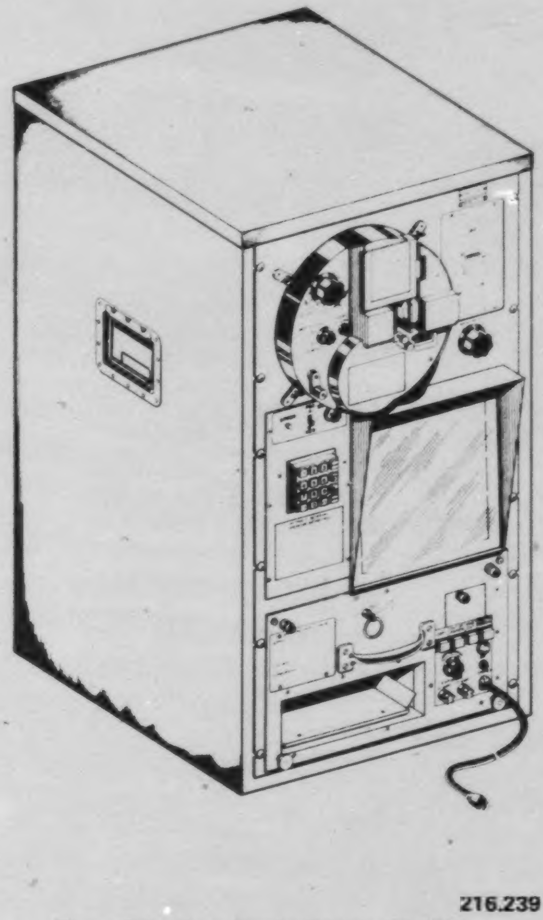
> "To the maximum practicable extent, avoid issuing repetitive Instructions. If the Navy Directives Manual is complied with, there can be no possible need for all of the duplication now existing. Directives should be complete enough so that no further repetitive issuance is necessary in the chain of command. There is evidence that many Instructions and Notices issued are not being complied with because there are too many for the individual units to keep corrected."

Before local directives are issued, the need for such Instructions and Notices should be established beyond doubt. A system to ensure timely revision or cancellation must be installed and maintained conscientiously. An Instruction which is not required or one which is out of date is at best a nuisance, and at worst a serious obstacle.

Conversion Of Manuals To Microfilm

A relatively new concept in supplying maintenance activities with certain types of technical data has been accomplished by the use of microfilm. As a means of improving updated manual availability and reducing stowage space numerous maintenance manuals and illustrated parts breakdowns are being placed on 16mm microfilm. The microfilm is stowed in cartridges, and a label on the cartridge indicates the type of projector that is required to enlarge the microfilm for reading.

There are many different types and models of microfilm printers and readers. Those with the ability to produce copies will do so within a matter of a few seconds. Coverage of the operation of all the various types and models is not appropriate for this manual. The AR-150A, Automatic Reader Printer, is covered in this section. See figure 2-6.



216.239

Figure 2-6.—Auto Reader-Printer AR-150A.

The Auto Reader-Printer provides a projected display of maintenance manuals from 16mm microfilm in cartridges. Microfilm frames can be selected for display by use of either a manually operated handwheel or internal film drive motors. A front-panel keyboard for automatic frame selection is also provided. Any image displayed on the viewing screen can be copied by use of the printer.

The Auto Reader-Printer consists of a case assembly (enclosure), a housing assembly, a transport optical assembly (TOA), a film control assembly, and a print processor assembly.

FUNCTIONAL DESCRIPTION.–The Auto Reader-Printer can be subdivided into three major functions as an aid in understanding the principles of operation. These functions are film transport and projection, frame retrieval, and printing.

Film Transport and Projection. This function, figure 2-7, consists of the film drive mechanism and the optics required for displaying a frame on the projection screen. The film is moved in a forward or reverse direction, along film guides, through the optical illumination area and wound onto an internal take-up reel.

The optics are diagrammed on figure 2-8. The projection lamp, cold mirror, condenser house mirror, and condenser lens provide illumination of the film. The glass flats, which can be closed by pushing the CLOSE control, hold the film flat to provide uniform focus. The glass flats will open automatically in MOTOR DRIVE mode when the film is moved.

Frame Retrieval. This function consists of locating a particular film frame for display or printing as desired. Operationally, frame retrieval can be accomplished by any one of three methods: automatic, manual motor driven, or manual handwheel.

Automatic frame retrieval is accomplished by entering a desired frame number at a keyboard when in the motor drive mode. At the film control assembly, the frame number is loaded into a destination register and then

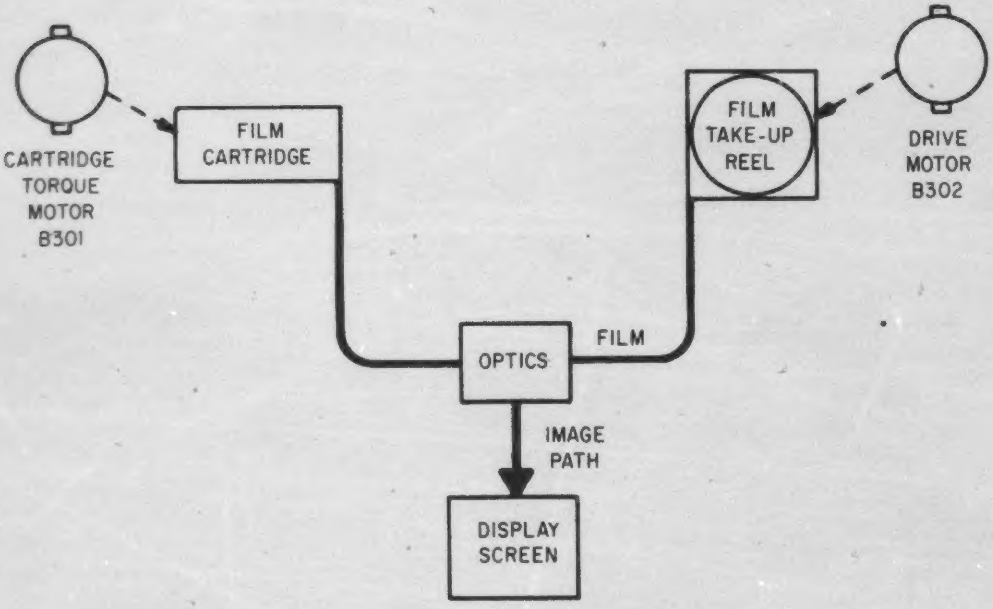


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Figure 2-7.—Film transport and projection block diagram.

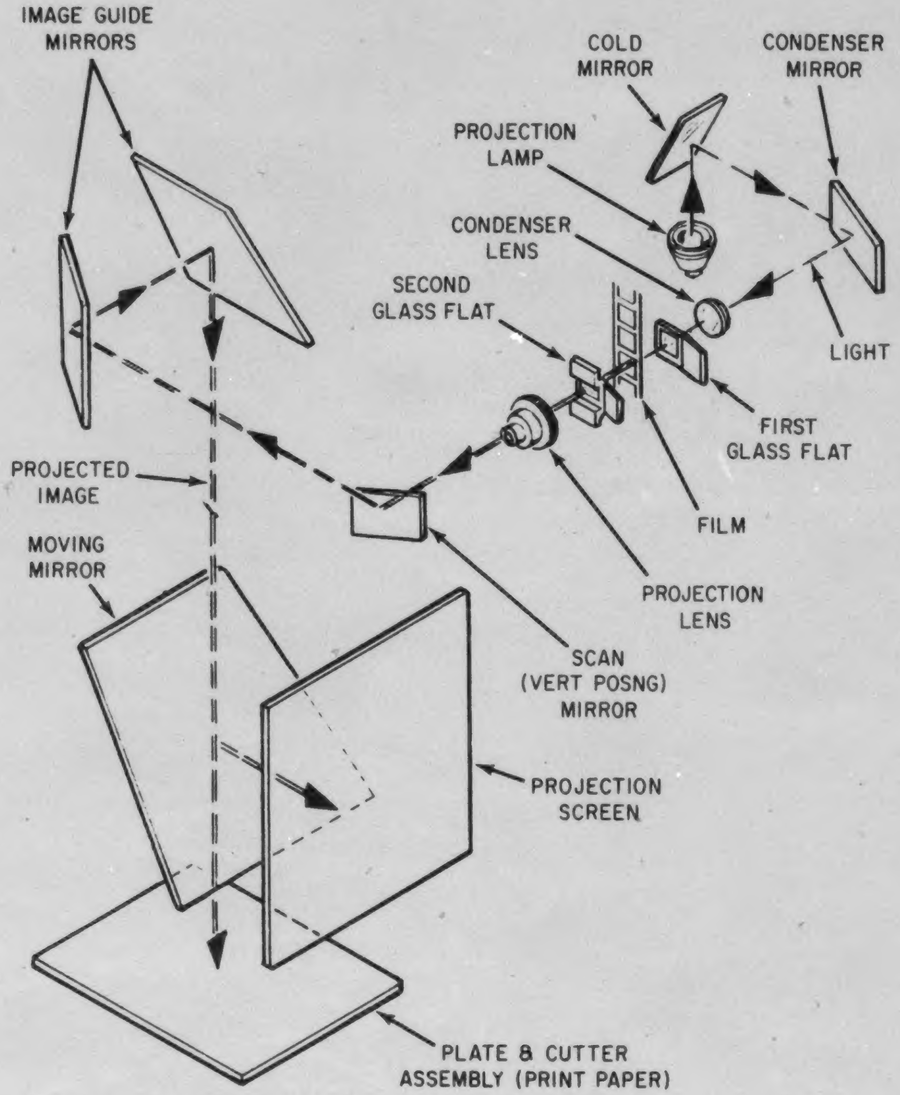


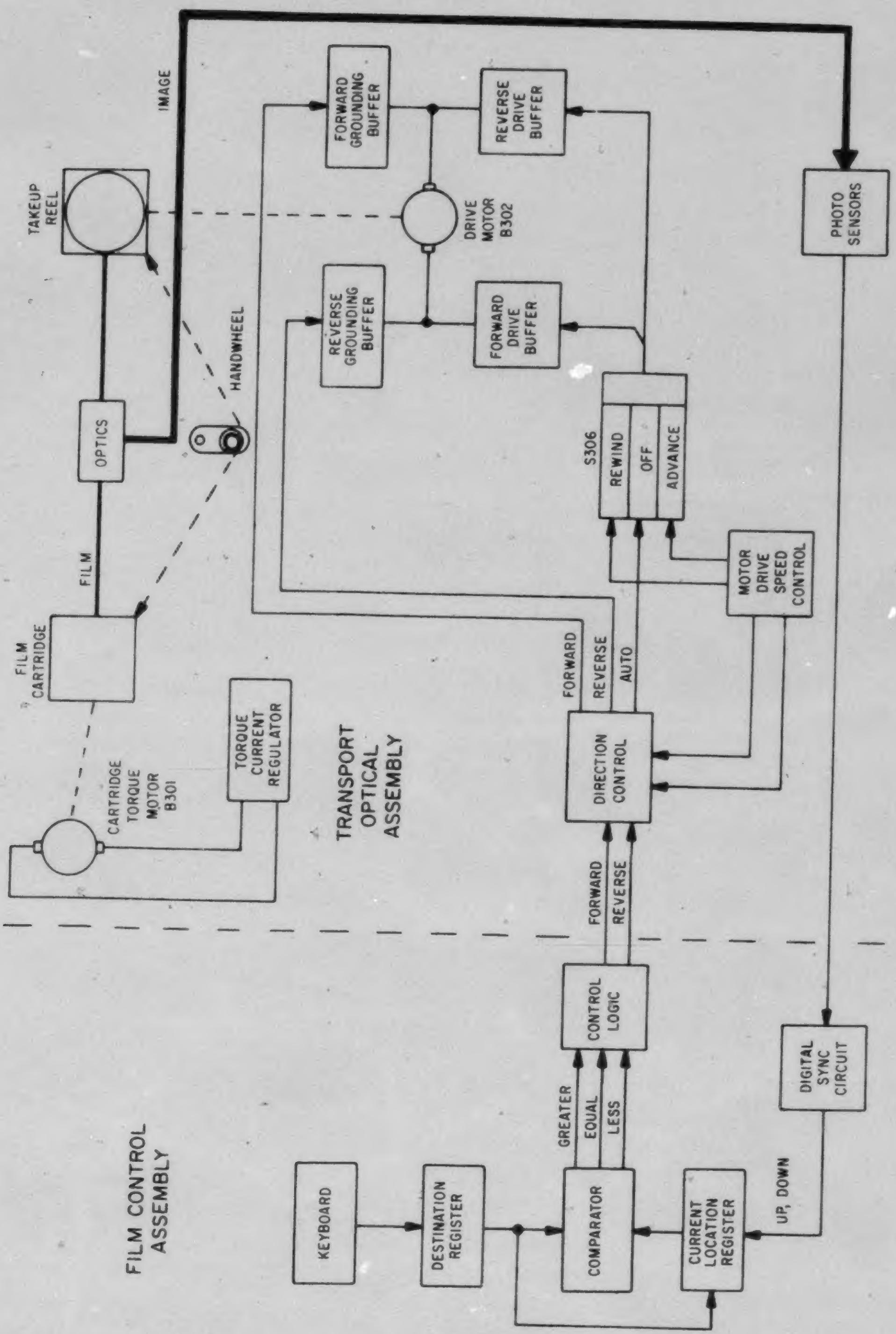
IMAGE GUIDE MIRRORS
COLD MIRROR
CONDENSER MIRROR
PROJECTION LAMP
CONDENSER LENS
SECOND GLASS FLAT
LIGHT
FIRST GLASS FLAT
PROJECTED IMAGE
FILM
MOVING MIRROR
PROJECTION LENS
SCAN (VERT POSNG) MIRROR
PROJECTION SCREEN
PLATE & CUTTER ASSEMBLY (PRINT PAPER)

216.241

Figure 2-8.—Optics diagram.

compared with the contents of a current location register. The result (greater, equal, or less) is applied to control logic which generates either forward or reverse commands. These commands are applied to direction control circuits at the transport optical assembly.

Manual motor driven operation (figure 2-9) is controlled by Motor Drive switch S306. This switch selects various voltage levels for application to the drive motor, and also programs the direction control circuit so that the drive motor is driven in the direction


FILM CONTROL ASSEMBLY
TRANSPORT OPTICAL ASSEMBLY
KEYBOARD
DESTINATION REGISTER
COMPARATOR
CURRENT LOCATION REGISTER
UP, DOWN
DIGITAL SYNC CIRCUIT
GREATER
EQUAL
LESS
CONTROL LOGIC
FORWARD
REVERSE
DIRECTION CONTROL
FORWARD
REVERSE
AUTO
MOTOR DRIVE SPEED CONTROL
S306
REWIND
OFF
ADVANCE
CARTRIDGE TORQUE MOTOR B301
TORQUE CURRENT REGULATOR
FILM CARTRIDGE
FILM
OPTICS
HANDWHEEL
TAKEUP REEL
IMAGE
REVERSE GROUNDING BUFFER
FORWARD DRIVE BUFFER
DRIVE MOTOR B302
FORWARD GROUNDING BUFFER
REVERSE DRIVE BUFFER
PHOTO SENSORS

216.242

Figure 2-9.—Frame retrieval block diagram.

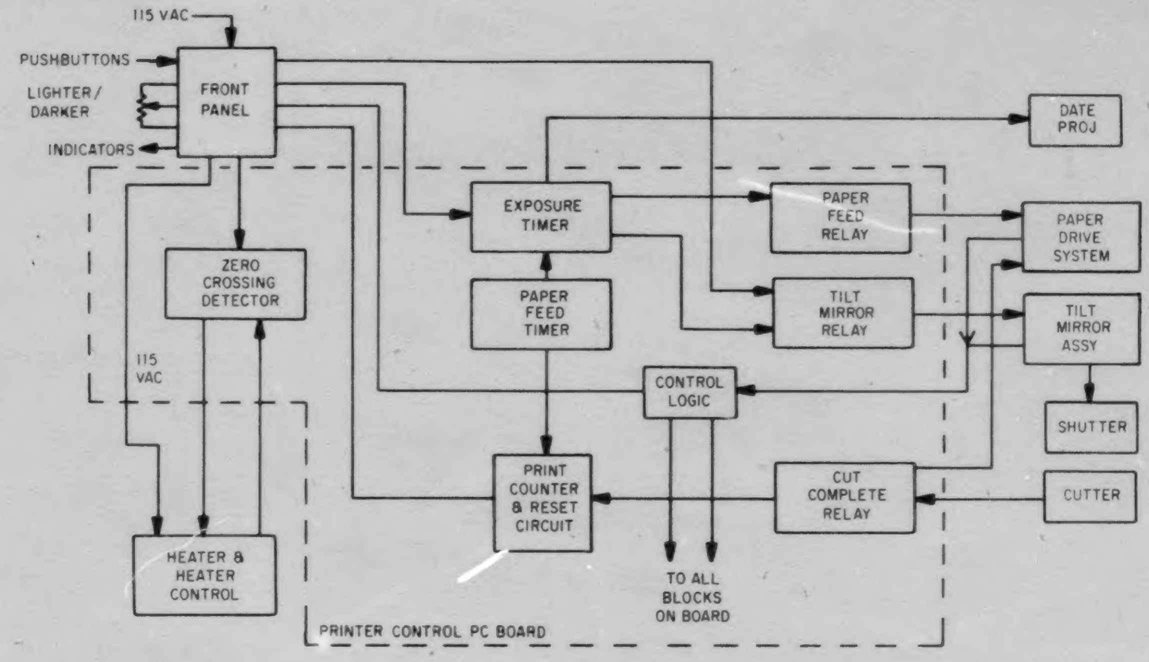
selected. The voltage amplitude determines the speed of the motor rotation. Returning the Motor Drive switch to OFF causes the drive motor to stop.

Placing the Mode Selector control in the HANDWHEEL position electrically disconnects the cartridge motor and mechanically disengages the motor drive mechanism from the take-up reel. Turning the handwheel clockwise engages the walking arm assembly with the take-up reel and advances the film, while turning the handwheel counterclockwise engages the walking arm assembly with the cartridge drive hub and rewinds the film.

Printing

This function consists of making a copy of a selected film frame(s). Single frames may be printed, or up to 7 consecutive frames may be printed for a continuous print (such as drawings). Figure 2-10 shows the major operations associated with printing. All print operations are controlled from the front panel assembly. Once the selected frame is positioned properly, depressing the COPY pushbutton starts the printing process. An OUT OF PAPER lamp informs the operator when to replace the paper roll, and a MUST CUT lamp lights after 7 continuous prints have been made. A manually operated cutter is operated to separate the exposed paper from the paper roll. The exposed paper is then developed. A date bar assembly provides a means of marking each print with the current month and day.

For more detailed information on the AR-150A and operation consult the *Operations and Maintenance Manual,* NAVAIR 17-4OMIARS-1.


115 VAC
PUSHBUTTONS
LIGHTER/ DARKER
INDICATORS
FRONT PANEL
DATE PROJ
EXPOSURE TIMER
PAPER FEED RELAY
PAPER DRIVE SYSTEM
ZERO CROSSING DETECTOR
PAPER FEED TIMER
TILT MIRROR RELAY
TILT MIRROR ASSY
115 VAC
CONTROL LOGIC
SHUTTER
PRINT COUNTER & RESET CIRCUIT
CUT COMPLETE RELAY
CUTTER
HEATER & HEATER CONTROL
TO ALL BLOCKS ON BOARD
PRINTER CONTROL PC BOARD

216.243

Figure 2-10.—Printing block diagram.

PROCUREMENT OF PUBLICATIONS

The publications covered in the previous section are specifically prepared to assist maintenance personnel; however, either through a lack of knowledge of their existence, the procedures for obtaining them, or plain indifference by supervisor personnel, the mechanic is often deprived of the benefits publications are intended to provide. Since the use of publications in performing maintenance tasks is mandatory, they must be on hand and used consistently.

Detailed information concerning the availability of aeronautic publications may be found in the *Naval Aeronautic Publications Index*. The complete index is made up of five parts, as follows:

NAVSUP 2002–*Stock List of Publications And Forms.*

NAVAIR 00-500A–*Equipment Applicability List.*

NAVAIR 00-500B–*Aircraft Application List.*

NAVAIR 00-500C–*Directives Application List.*

NAVAIR 00-500M–*Microfilm Cartridge Cross Reference.*

NAVSUP 2002 contains a complete numerical stock listing of all available naval aeronautic publications distributed by NavAirSysCom and stocked for issue as of the date of publication. This numerical listing contains all available publications by publication number, stock number, and title. Publications are subdivided into subject groups according to type of aircraft or equipment, or component thereof. The NAVSUP 2002 is no longer issued in manual form, it is now printed on MICRO FICHE.

Letter-type technical directives are listed in Section III numerically by type and directive number. They have, however, been grouped into major sections identical to the major groups of NAVAIR manuals. For example, general, aircraft, accessories, armament, avionics, etc., and into subseries according to weapon system model number or component category.

The Stock List must be used to completely identify and, therefore, to order required publications. However, the other parts of the NAPI (discussed in the following paragraphs) must be used to determine what publications are available for a specific item of equipment and to check the applicability of publications to specific equipment.

When an applicable publication number is found in one of the other parts of the *Naval Aeronatuic Publications Index*, it can be easily located in the Stock List. Here, it can be more completely identified as to title and nomenclature, stock number (for manual type publications), security classification, and any restrictions concerning the requisitioning of the publication. In addition, the date of the latest issue or revision of the publication is listed. This provides a means whereby the issue and/or revision dates of the publications on hand in an activity can be checked against the dates listed in the current issue and supplement (discussed later) of the Stock List, thus assuring that the publications are current.

Equipment Applicability List

Basically, the Equipment Applicability List, NAVAIR 00-500A, is a cross-reference index listing of Naval Air Systems Command (NAVAIRSYSCOM) publications of aircraft components and related equipment according to model, type, or part number.

Since this index contains several thousand entries, one volume would be very cumbersome to use. For this reason, this index is divided into several volumes. At the time of this writing, there are seven volumes.

With the exception of several small sections in the first part of Volume 1, the *Equipment Applicability List* is one continuous index of model, type, or part number in alphanumerical sequence.

In addition to an Introduction, which explains the headings at the top of each page, the other sections in the first part of Volume 1 pertain primarily to manuals for aircraft, weapons systems, and aircraft engines. Therefore, the publication numbers are listed according to aircraft, aircraft engine, and weapons system designation.

The *Equipment Applicability List* should be used when attempting to determine what publications and technical directives are available on a particular item of equipment, and the manufacturer and part number of the item are known.

Aircraft Application List

The *Aircraft Application List,* NAVAIR 00-500B, contains a listing of all manuals grouped according to their application to an aircraft. This part of the index does not contain listings of any letter type publications, and all manuals are listed by publication code number only.

A list of basic numbering categories is provided in the front of the book. This list may be used in determining the general type of equipment covered in a publication. For determining the specific item of equipment covered by a publication and the title of the publication, reference should be made to the NAVSUP Publication 2002.

The *Aircraft Application List* is especially handy for determining what manuals are available for a particular model of aircraft. Included under each model is a complete listing of applicable manuals. This listing includes all allowance lists, aircraft manuals, engine manuals, accessories manuals, etc., pertaining to that particular model of aircraft.

Directives Application List By Aircraft Configuration

The *Directives Application List by Aircraft Configuration,* NAVAIR 00-500C, contains a listing of the active Naval Air Systems Command letter type technical directives with respect to their applicability to aircraft. The lists in this volume are arranged first by aircraft series, second by aircraft configuration, and third by Airframe/Aircraft Bulletin and/or Change numbers.

NOTE: Configuration refers to modifications made to a basic aircraft model. For instance, A-4A, A-4B, TA-4F, etc., are all different configurations of the A-4 aircraft model.

Each list in the *Naval Aeronautic Publications Index* is updated at regular intervals by the issuance of a new list. In addition, some of these Lists are kept current by the periodic issuance of supplements between issues of the Basic List. The dates and intervals of the issuance of new Lists and supplements have changed from time to time in the past.

The *Equipment Applicability List,* NAVAIR 00-500A, is issued annually in November. This List is kept current by the issuance of quarterly supplements between each basic issues. The *Aircraft Application List,* NAVAIR 00-500B, is issued in March and September, and the *Directives Application List by Aircraft Configuration,* NAVAIR 00-500C, is issued in January and July of each year. Supplements are not issued for these Lists.

Supplements list all aeronautic publications distributed during the previous period, and those publications that have been superseded, canceled, or revised. Supplements are cumulative, that is, all material from the preceding supplement is incorporated in the latest supplement; therefore, at any given time, not more than one supplement is in effect for any List. Naturally, the reissue of a basic List cancels the outstanding supplement.

Procurement Methods

There are 5 main methods of procuring publications relating to naval aircraft maintenance.

The first method is initial outfitting. The Naval Air Technical Service Facility (NATSF) will provide the prospective commanding officer of a newly commissioned or reactivated ship, station, or activity an outfitting of aeronautic publications. Normally this outfitting will be furnished 2 months prior to commissioning unless otherwise requested.

The second method is aeronautic technical publication outfitting. An Aeronautic Technical Publication Outfitting Allowance consists of those publications applicable to a particular model of aircraft. Initial distribution is provided by the Naval Air Technical Service Facility to a newly commissioned or reactivated activity. Upon change in mission or aircraft custody which requires a different set of publications, the activity must submit a request to the Naval

Air Technical Services Facility for an Aeronautic Technical Publication outfitting Allowance, applicable to the model designation of the aircraft involved.

The third method of procuring publications is through inclusion on automatic distribution lists. The Naval Air Technical Services Facility normally provides for the distribution of certain future issues of new and revised publications directly to affected activities. Activities desiring to receive future issues of new and revised publications must submit NAVAIR Form 5605/3, Mailing List Request for Aeronautic Publications, to the Commanding Officer, Naval Air Technical Services Facility, 700 Robbins Avenue, Philadelphia, Pennsylvania 19111. AMH work center supervisors desiring to receive particular issues, reissues, and revisions of publications should make their requirements known to the maintenance office and/or the activity's technical publications library so that they may be included on the next submission of NAVAIR Form 5605/3.

NAVAIR Form 5605/3 consists of four separate parts:

Part I contains requirements for *General Allowance Lists, Indexes,* and *General Series Technical Manuals and Directives.*

Part II contains requirements for Aircraft/Engine Allowance Lists, and Airframe and Power Plat Technical Manuals and Directives.

Part III contains requirements for Aircraft Component Manuals.

Part IV contains requirements for Ship Installation Technical Manuals and Directives.

Technical Manuals And Directives

Instructions for submission of NAVAIR Form 5605/3 are printed on page I of each part. The parts may be submitted separately or as a group, as long as the appropriate block in the instructions is checked to indicate the reason for submission. The newly submitted form will place an activity on the mailing list for FUTURE ISSUES of Basic, Revised, or Changed manuals/directives only. It is not used as an order blank for existing manuals/directives.

The fourth method of procuring publications is by ordering individiual publications direct. The Single Line Item Requisitioning System Document (DD Form 1348 or DD Form 1348M) is used by activities when requisitioning manual type publications on a one-time requirement. Letter type publications may be ordered on DD Form 1149 Standard Requisition and Invoice/Shipping Document, on a one-time requirement. The use of DD Form 1348, DD Form 1348M, or DD Form 1149 will not result in being placed on the distribution list to receive future issues or revisions of the publication ordered. Unless otherwise directed, individual publications are ordered from the Commanding Officer, (1051), Naval Publications Form Center (NPFC), 5801 Tabor Ave., Philadelphia, Pennsylvania 19120.

A limited number of publications may be ordered utilizing telephone requisitioning procedures. This is accomplished by contacting the customer service branch of the Naval Publications Forms Center. The same information as would be placed on an order form should be obtained prior to placing the telephone call, thereby improving accuracy and expediency over this communications media.

Although Interim Changes and Bulletins are listed in NAVSUP Publication 2002, they are not available for issue through the Publications Supply System. They are listed only for informational purposes.

Operating activities requiring copies of Interim Technical Directives should submit requests to the appropriate controlling custodian. Other activities requiring copies of ITD's in addition to the initial NAVAIR distribution, should submit requests to the appropriate Naval Air Systems Command Representative.

Instructions issued by Washington headquarters organizations such as OPNAV, BUPERS, SECNAV, NAVAIR, etc., are listed in the *Consolidated Subject Index of Unclassified Instructions,* NAVPUBINST 5215 Series. They are requested on NAVSUP Form 1205 from the Supply and Fiscal Department, Washington, D.C.

Requests for instructions from other than Washington headquarters organizations may be initiated on NAVSUP Form 1205 by submitting a letter request in accordance with the originating activity's 5215 index of instructions.

NAVAIR Specifications and Standards and NavAir Standard Drawings are listed in NAVAIR 00-25-544 and NAVAIR 00-25-543, respectively. The Department of Defense Index of Specifications and Standards (DODISS) and related documents, Part I (alphabetical listing) and Part II (numerical listing) provide a more complete listing of specifications and standards of interest to work center supervisors. Specifications, standards, and drawings are ordered on DD Form 1425.

In addition to the NAVAIRSYSCOM, the NAVSUP 2002 provides instructions on requesting this type of information. Other commands publish a variety of material which may also be useful. If this type material is desired and is not listed in the NAVSUP 2002, a request by letter directly to the publishing command should bring results.

Fleet and type commanders publish a limited amount of material, normally relating to operational problems in their respective areas. This material is usually supplied automatically to activities on the standard mailing list. If other requirements exist, a letter request may be submitted to the applicable fleet or type commander.

Situations may arise in both organizational and intermediate levels of maintenance which require the use of engineering drawings. Technical information of this type is normally supplied to these levels of maintenance in the form of microfilm reproductions of the actual drawings. Engineering drawing reproductions provide all the necessary information to construct, assemble, and install a part of an assembly Aircraft and equipment manufacturers provide NATSF and Naval Air Rework Facilities with engineering drawings for use by engineering and repair personnel. These activities are also provided with microfilm and Vandyke (blueprint) copies of engineering drawings.

For the most part, microfilm copies of engineering drawings are provided in filmstrip and in single frames mounted on aperture cards. Aperture cards are standard size EAM cards and have printed and keypunched identifying information concerning the frame of microfilm which they contain. It is conceivable that reproductions of engineering drawings may, in the future, be provided in cartridge form for use by the reader printer previously discussed.

Most aircraft and equipment IPBs contain manufacturer's engineering drawing numbers for various components. If microfilm of a particular drawing is required and the drawing number unknown, then the aircraft or equipment company technical representative should be consulted for this information.

In most cases the requirement for microfilm of engineering drawings will be on an as needed basis; therefore, large stocks will not normally be maintained in the technical library of organization and intermediate activities. The various work center supervisors will normally notify the person in charge of the technical library of their requirement for microfilm of engineering drawings.

All requests for complete sets of engineering drawings should be forwarded to the Commanding Officer, U.S. Naval Air Technical Services Facility (EDD), 700 Robbins Avenue, Philadelphia, Pennsylvania 19111, on a DD Form 1149. When a complete set of drawings for aircraft equipment is requested, the individual drawings need not be listed; however, the request must be accompanied with a statement of justification. Individual drawings may be obtained either from NATSF or the nearest NAVAIRREWORKFAC, via the cognizant NAVAIRSYSCOMREP. Requests for classified and unclassified drawings must be submitted on separate forms. Proper submission of requests for copies of these drawings is essential to avoid delay in receipt.

SECURITY OF CLASSIFIED PUBLICATIONS

The problem of security of classified publications in the work center files is generally limited to ways and means of stowing, using, accounting for, and disposing of such publications in accordance with existing directives. The basic Navy security directive relating to the safeguarding of classified information is the Department of the Navy Supplement to the DOD Information Security Program Regulations, OPNAV Instruction 5510.1 (Series). Its provisions apply to all military and civilian personnel and to all activities of the Naval Establishment. The application of security measures regarding work center files may be further influenced by locally issued directives which supplement the basic directive.

All personnel in the Navy Establishment are individually responsible for assuring that knowledge of classified information which they prepare or handle is made available only to persons who have clearly established a legitimate "need to know." Classified material is procured for the files because it is needed during the performance of some related maintenance function. Use of these publications by AMH personnel should be anticipated and steps taken to procure security clearances for selected personnel most likely to require the information.

The supervisor must initiate procedures that ensure him positive control of all classified publications for which he is custodian. The first problem of custody is stowage. The Navy Security Manual discusses stowage containers of varying degrees of integrity. Also provided in the manual are specific requirements for safeguarding combinations and keys for locks, as these, to various extent, affect the protective capabilities of the different types of containers.

Classified publications that are no longer required in the work center or that have become obsolete should be returned to the Classified Material Control Officer for disposition by transfer or destruction, as appropriate.

Commanding officers are responsible for establishing security orientation, education, and training programs for all personnel assigned. OPNAV Instruction 5510.1 (Series), chapter 3, provides the necessary minimum requirements for implementing these programs.

The central aim of the security education program is to make all personnel "security-minded." To achieve this, a continuing training program must be in use at all levels of the command, with emphasis by the senior petty officers to their subordinates.

Effective security also requires that the handling of classified materials be managed in an efficient manner. Good management practices are important in obtaining effective security control. If security needs are to be met, constant attention must be given to the way in which classified material is handled.

Security Orientation, Education, And Training Program

The security orientation, education, and training program of each command must include all personnel entrusted with classified information regardless of their position, rank, or grade. The program must be designed to include the following:

1. Familiarize all personnel with the security requirements with which they have to comply for proper performance of their duties and assignments.
2. Remind all echelons of command of their responsibility for assuring that classified defense information is effectively and economically safeguarded.
3. Ensure willing, conscientious compliance with security regulations, procedures and practices.
4. Remind all echelons of command of their responsibilities in the classification management program to include classification, upgrading, downgrading and declassification processes as set forth in OPNAV Instruction 5510.1 (Series).
5. Advise all personnel who have access to classified information of the hazards of its disclosure to any person not authorized to receive it and of their responsibility for exercising personal vigilance for its protection.
6. Inform all personnel of the techniques and devices employed by foreign intelligence activities in attempting to obtain U.S. classified defense information and of their responsibility for reporting such attempts.
7. The attention of all personnel must be directed to the disciplinary action (Article 0815 of OPNAV Instruction 5510.1 (Series)) that may result from violation of security regulations.

Personnel Indoctrination

Persons being assigned to duties requiring access to classified information, prior to being granted access, must be indoctrinated on the security aspects and responsibilities of their assignment. The indoctrination must include the strict prohibition against discussing classified information over the telephone. This is especially important because of the fact that many calls are transmitted through microwave transmitters and can be easily recorded and analyzed. The types of situations to be avoided when talking on the telephone are:

1. Allowing classified information to slip into conversations through carelessness.
2. Disclosure of classified information in order to expedite the completion of a "rush project."
3. Use of codes, "double talk" or attempt to talk around classified information. It should be noted that private codes and "talking around" classified matters presents no real protection against the abilities of a trained analyst.

As part of the indoctrination program, personnel must be instructed to report promptly any of the following types of information:

1. Attempts by representatives or citizens of communist controlled countries to cultivate friendships or to place personnel under obligation.
2. Attempts by representatives of citizens of foreign governments to:
    a. Cultivate a friendship to the extent of placing them under obligation, which they would not normally be able to reciprocate, or by money payments or bribery to obtain information of intelligence value.
    b. Obtain information of intelligence value through observation, collection of documents, or by personal contact.
    c. Coerce personnel by blackmail; by threats against or promises of assistance to relatives living under their control, especially those in a communist country.
    d. Appeal to personnel on a racial, nationalistic, or ideological basis.
    e. Exploit personnel who may be disaffected or in personal difficulties.
    f. Intimidate, harass, entrap, discredit, search, spy on, or recruit for intelligence purposes personnel traveling in communist countries.
    g. Induce personnel to defect or to induce those who have fled from communist countries to redefect.
3. Attempts by Department of the Navy personnel to provide unauthorized services, information, or documents to anyone believed to be in contact with a foreign intelligence service.
4. Attempts by persons living in communist countries to obtain information of intelligence value from personnel by correspondence (including "Pen Pal" correspondence), questionnaires, "ham radio" activity, naval cachets (request to service postal covers), or other forms of communications.
5. Careless handling of classified material and failure to properly secure classified material containers.

Senior petty officers to whom information of the above nature becomes known must:

1. Instruct the reporting individual to take no action to exploit, apprehend, restrict, or stimulate further contact until appropriate guidance or instructions are received.
2. Report full details expeditiously to the commanding officer who should report his findings to the nearest Naval Investigative Service Officer or take whatever appropriate action is required, dependent on the nature of the violation.

WORK CENTER FILES

There are two general categories of records required of all work center supervisors. These include records required by the activity for operation purposes and those needed by the supervisor for the efficient management of his work center. It is advisable to keep the system of records as simple as possible and still maintain the necessary control. Too many records can lead to duplication, wasted manhours, outmoded instructions, and in general complicate what should be simple, workable, work center file system. On the other hand, too few records can lead to uncertainty, encourage guessing, and sometimes lead to embarrassing situations.

Retention of obsolete and inactive correspondence and records is costly. Such correspondence and records should be destroyed or transferred in accordance with approved records disposal instructions. If this is not performed periodically, the volume of file space required becomes excessive and the files become unwieldy, thus inefficient. The destruction of records is governed by law which requires authorization by proper authority. The authority for destruction of Navy records is contained in SECNAV Instruction 5212.5 (Series), *Disposal of Navy and Marine Corps Records.*

The provisions of SECNAV Instruction 5212.5 (Series) are normally amplified by the issuance of local instructions outlining the procedures as they apply locally.

Not all materials in the files have a record characteristic. In fact, most printed matter found in the maintenance department general files fall in the category of nonrecord material. This includes documents that are copies of those filed in the activity's administrative department or other material that has been reproduced and never acquired a record characteristic themselves.

SECNAV Instruction 5212.5 (Series) (part II for shore stations and part III for ships) contains the retention standard for naval records. Record materials are listed by broad subject and the retention period is furnished. Nonrecord material may be destroyed locally as soon as it has served its purpose. Records material may be destroyed upon completion of the retention period.

Unclassified records or nonrecords material authorized for destruction may be placed in wastebaskets and disposed of in the normal manner for trash. Classified material authorized for destruction is turned over to the classified material control officer for disposal. Classified material is destroyed by burning or in some cases by shredding so that reconstruction of the material is impossible. Destruction is accomplished in the presence of two designated witnesses who must have clearances at least as high as the category of material being destroyed.

In order for records to be of maximum benefit and provide adequate control, it is necessary that they be filed in the work center in such a manner that they may be quickly located and readily available for use by all personnel concerned; this includes technical publications.

The Navy has adopted a filing system which provides a definite place for every piece of correspondence and uniformity in filing systems throughout the Naval Establishment. This filing system is an integral part of the Navy Directives System (SECNAV Instruction P5215.1 Series). The standardized filing system is based on assigning numbers to the correspondence according to its subject. SECNAV Instruction P5210.11 (Navy–Marine Corps Standard Subject Classification System) lists the subject numbers, and they are standard for all Navy activities.

While directives (Instruction and Notices) utilize the standardized subject classification system, many other publications do not. When file material other than Instructions and Notices is received in the work center, it should be assigned a file symbol (subject classification number) based on the subject group classification system. The correct application of file symbols assures uniformity in filing.

Personnel who have a working knowledge of the subject classification system and the manner in which all records are filed can locate required material more expeditiously at any activity to which they may be assigned.

The most important step in recordkeeping is classifying (assigning file symbols) since it determines where papers are to be filed so that they may be located quickly. Each paper received in the work center that must be kept for filing should have the work center file symbol assigned regardless of whether or not a file symbol already appears on it. The proper classification should be determined by the most important, definite, or concrete subject mentioned; the purpose or general significance of the document; the manner in which similar documents are sought; and the file symbol under which other documents of a similar nature are filed.

The actual filing responsibility should be assigned to one person in the work center. All material awaiting filing should be placed in one basket only, and to avoid accumulations, should be filed daily.

In addition to proper filing, another handy tool for keeping work center files in good order is the "file out" card. This may be a locally prepared form that is inserted into the files whenever a piece of file material is charged out to another office, work center, or person, to help keep track of its whereabouts. All "file outs" should be checked periodically to prevent misplacement of material. Care must be taken that records are not released to unauthorized persons.

Filing of publications such as technical manuals should be done by use of looseleaf binders. These publications should be placed on looseleaf binders in numerical order and kept in a convenient shelf. The binders should be clearly marked on the back with the contents for ease in locating a particular publication or directive.

REQUIRED READING AND MAINTENANCE INFORMATION RECORD

Certain directives and publications are routed to the various work centers as maintenance information, and copies of such maintenance information must be disseminated and retained until it is no longer applicable. Information should be placed in a required reading file that is available to all hands in the work center. When new material is received, it is placed in the "active" required reading file until it is read and initialed by each man in the work center. It may be necessary for the work center supervisor to amplify or clarify some information so that it will be properly understood.

Once all personnel in the work center have read and initialed the material, it is placed in the "standing" required reading file for use in indoctriniating new personnel and for periodic review by those personnel who may require it. Newly assigned personnel should read and initial both the active and standing file. If copies of directives or publications are not available for the required reading file, a cross-reference sheet inidicating the general content of the subject matter and its location is utilized to ensure that personnel are thoroughly aware of all information that could affect their actions.

PERSONNEL MANAGEMENT

One of the problems that a supervisor will encounter is that of personnel management. The supervisor must realize the importance of long range planning to ensure that his personnel are trained and available to complete scheduled deployments.

To assist the operating activities in their personnel management, a Manpower Authorizations, OPNAV Form 1000/2, is furnished each activity listing by pay grade and NEC the number of personnel authorized. The authorized manpower is the result of extensive study by NAVAIRSYSCOM; it is based on the weapons system, the type of operations being conducted, and the recommendations of the supplying contractor.

It is the responsibility of the supervisor to compare both the number and grade of personnel and their NECs with the authorizations. Any variation in the two should be reported to the department/division officer as appropriate with recommendations based on facts.

If the manpower authorizations differ (in number, pay grade, or NEC) from actual requirements of the organization and this difference cannot be corrected by training, this should be reported to the department/division officer. A Manpower Authorization Change Request, OPNAV Form 1000/4A, should be initiated to request appropriate changes. OPNAV Instruction 1000.16 (Series) provides instructions for preparation of Manpower Authorization Change Requests.

A document which the supervisor should utilize in the management of personnel is the Enlisted Distribution and Verification Report (BUPERS 1080-14). This monthly report, which is normally maintained in the Enlisted Personnel Office, contains a multitude of information such as expiration of enlistment, time in service, NEC codes, and projected rotation month. For those activities classified as shore duty, the tour completion date reflects the month and year a man is to be transferred; for sea duty activities, the report indicates the month and year that the man's sea duty commenced.

Personnel who have been ordered to report for duty are also covered by the report.

Utilization of this report by the AMH supervisor permits long range personnel planning for school quotas, leave, and rotation of billets within the division or work center.

SCHEDULING AND ASSIGNMENT OF WORKLOADS

Among the most important factors with which the Chief or First Class Aviation Structural Mechanic H is concerned as a supervisor are the assignment and accomplishment of the scheduled workload. His objective is the satisfactory completion of assigned tasks in a reasonable length of time, utilizing available men and materials as efficiently as possible. In order to achieve his objective, the supervisor must become skilled in estimating the amount of time to allow for the completion of each task and estimating the number of workers required. He must realize the importance of assigning both qualified and unqualified men to the jobs, consistent with his training program. The supervisor must allow for planned interruptions and yet not operate on so tight a schedule that minor, unplanned interruptions completely disrupt his schedule.

MALFUNCTION ANALYSIS

The amount of time required to analyze malfunctions will have a direct relationship on the length of time that will be required to effect repairs of an unscheduled nature. The length of time required to analyze a malfunction will depend on several factors–the experience level of personnel assigned to the job, availability of test equipment, availability of replacement parts, the nature of the malfunction, the thoroughness of troubleshooting/trouble analysis charts and procedures provided in the Maintenance Instructions Manual, etc. The cause of some malfunctions can be elusive and difficult to pinpoint. The supervisor who is familiar with the weapon system or equipment and makes full utilization of his experience and knowledge will be able to provide realistic estimates on trouble analysis and repair times. Documenting excessive or significant troubleshooting time separately from actual repair time will provide recorded maintenance data that can be utilized for such estimates. The procedures involved in malfunction analysis are covered throughout this manual.

ESTIMATING TIME AND PERSONNEL REQUIREMENTS

Most aircraft maintenance jobs are of such a nature that the quality and quantity of people assigned to do them directly affect the time that will be required for completion. For this reason, time requirements and personnel requirements are combined and discussed together in this section.

Probably the most important single aid in estimating time and personnel requirements for aircraft maintenance tasks is the Maintenance Requirements Cards. Extensive time and motion studies of the various inspection requirements have been made and completion times are furnished in manhours or manminutes. These times also reflect routine maintenance adjustment, and replacement if required in connection with the aircraft inspection. They are calculated on the basis that the most efficient number of men are continuously employed and that all necessary equipment, tools, and parts are immediately available. The supervisor must consider all these factors from the knowledge of his individual personnel, supply, and equipment situation, together with an accurate determination of the extent to which the maintenance task at hand exceeds the inspection requirements if he is to reliably predict the completion time. While this procedure may seem rather involved at first, the new supervisor will find that it is based on sound management principles and that, with experience, his ability to accurately predict time and personnel requirments will speedily improve.

Maintenance procedures in most Maintenance Instructions Manuals provide the recommended manpower requirements but not the estimated time to accomplish the task. The ability to estimate the time required to complete various tasks will come through experience and reference to maintenance data forms which might reflect the time required to complete previous discrepancies of a similar nature.

PERSONNEL WORK ASSIGNMENTS

Work assignments should be rotated so that each man will have an opportunity to develop his skills in all phases of the AMH work. When assignments are rotated, the work becomes more interesting for the men. Another good reason for rotating work assignments is that if one highly skilled man performs all the work of a certain type, the supervisor and the work center would be at a great disadvantage in the event the man is transferred. Less experienced personnel should be assigned to work with him in order to become proficient in his particular skill. Also, in order to broaden his knowledge of his rate, the expert on one job should be rotated to other tasks when there is no immediate need for his particular skill.

Strikers should be assigned to various tasks so that they will acquire experience on all kinds of jobs. A special consideration for the assignment of strikers to jobs is that they should be assigned progressively to jobs of ascending levels of difficulty. A striker may be useful assistant on a complicated job, but he may not understand what he is doing unless he has worked his way up from basic tasks.

ALLOWING FOR PLANNED INTERRUPTIONS

During an average workday, occasions will arise when personnel have to leave their working spaces for one reason or another, thereby delaying the completion of the scheduled work. Some delays can be anticipated; some cannot. Among the delays which can be anticipated are training lectures, immunization schedules, flight schedules, rating examinations, meals, and watches or other military duties.

Before making personnel work assignments the supervisor should determine what delays can be anticipated. It may be possible to arrange assignments so that work interruption is held to a minimum. When estimating the completion time of an aircraft maintenance task, the supervisor should allow for these predictable delays.

INSPECTION OF COMPLETED WORK

All work completed by the work center is subject to inspection by the squardon or unit quality assurance representatives. This fact in no way relieves the work center supervisor of the responsibility for checking on the quality of work accomplished by his work center. Frequent inspections should be made during the progress of the work as well as after completion. The supervisor's inspection should provide affirmative answers to the following questions:

1. Is the work done according to current directives?
2. Do technical materials used conform to specifications?
3. Is the job complete in all respects?
4. Does the workmanship measure up to desired standards?

When parts or components are removed or installed, the supervisor should ensure that the necessary functional checks are performed in accordance with the existing directives.

When an aircraft maintenance job has been finished, the crew leader is required to complete the Maintenance Action Form. An important function of the supervisor is the review and evaluation of the completed MAF. The purposes of the supervisor's review and evaluation are listed below, not necessarily in order of importance:

1. Determine completeness. Ascertain if entries are made in every space required of his work center.

2. Evaluate the items on the completed MAFs which inidicate that discrepancies have been found and corrected or parts replaced. Ascertain if causes were determined for each discrepancy and evaluate correctness of steps taken to eliminate these causes. Determine if any combination of discrepancies indicates improper operation or incipient failure of a related part, component or assembly.

3. Note manhours expended. Determine if estimated maintenance time is realistically reflected in the crew leader's report of manhours used. This may be used as a rough indication of the efficiency of the inspection crew.

On certain aircraft components and accessories, an accurate and complete maintenance history including installation, removal, operating time, technical directives complied with, etc., is required. The Scheduled Removal Component Card (SRC) is designed to provide the necessary history information. Components requiring an SRC are listed in the Periodic Maintenance Information Cards (PMIC) for each specific aircraft.

The cards are maintained in the Aircraft Logbook or the Aeronatucial Equipment Service Record (AESR) located in the maintenance control work center. The AESR is a loose-leaf log contained within a separate cover. Presently, the only specific equipments pertaining to the AMH that require an AESR are low-level ejection systems.

When a component is removed from the aircraft the SRC Card or, if applicable, the complete AESR must be properly annotated and accompany the component. As it is processed through the supply channels and higher levels of maintenance for repair, incorporation of technical directives, and ultimately returned to a ready-for-issue condition, the card must accompany the component so that there is a continuity of the maintenance history recorded.

When a replacement part that requires an SRC card is received by a maintenance activity, the SRC card should either be attached to the component or inside the box or container in which the component is shipped. The SRC card should always be placed in a plastic return material documents envelope separate from other shipping documents. Components that are received without the required SRC card should not be considered as ready for issue by supply or accepted for installation by the maintenance activity.

Since many SRC cards have been lost in the past, special handling is necessary to reduce the possiblity of loss. Such losses have a definite impact–upon the logistics assets available to using activities, overhaul scheduling, and loss of usable operating time on the component.

Cards received with replacement components should be immediately turned over to the activity's maintenance production control work center for inclusion in the appropriate Aircraft Logbook or Aeronautical Equipment Service Record. Maintenance personnel finding any SRC card that is separated from its associated component should turn it in to the maintenance control work center. If local attempts to locate the associated component fail, the card is forwarded to the central repository for SRC cards in accordance with OPNAV Instruction 4790.2 (Series).

Entires on the SRC cards are made by designated personnel of the AZ rating or other designated and qualified personnel assigned to the maintenance control work center. The AMH supervisor should ensure that all personnel in his work center are aware of the necessity of proper handling of the SEC cards to reduce the possibility of their loss.

WORK CENTER QUALITY ASSURANCE

Commanding officers are responsible for the inspection and quality of material under their cognizance. In a maintenance department, the principal force for securing compliance with quality standards lies NOT in the instruments, instructions, or other facilities for inspection, but in the state of mind of maintenance personnel, from the commanding officer down to the plane captain.

Generating quality in a maintenance organization necessitates a sincere interest on the part of commanding officers, plainly evidenced to the officers and men in their commands. Quality further requires that each maintenance officer and supervisor understands clearly how the accomplishment of a quality job contributes to the effective operation of the organization. Quality also requires each maintenance worker to understand not merely a set of specification limits, but also the intent and the need for these requirements.

To be effective, an activity's quality assurance program must be well formulated, then followed in an active, aggressive, continuous, and positive manner. The attitude of the work center supervisor towards support of quality assurance should be such that all work center personnel will understand the program and give it their full support. Instituting and maintaining a good quality assurance program is not a simple task, but it is a "must" if maintenance-caused mishaps are to be reduced.

FUNCTIONAL AREAS

The quality assurance organization is concerned with three functional areas–quality management, quality verification, and technical publications.

Quality management is monitored by formulating, implementing, and auditing procedures, instructions, and operations to assure compliance with the policies stated or implied within the NAMP Manual. Quality assurance coordinates their efforts with those of the activity's data analysis group to provide information on maintenance practices and results based on facts gleaned from the various maintenance source documents and associated reports.

Quality verification assures that all materials processed and actions taken by maintenance personnel meet prescribed quality requirements. Direct inspection of material and operations as they are performed is necessary on a continuing basis to give adequate assurance that all items processed and maintenance tasks completed meet the prescribed requirements. These quality assurance considerations (tests, inspection, etc.) are included in most weapon system Maintenance Requirements Card decks as well as most Maintenance Instructions Manuals and Overhaul and Repair Manuals (03). Quality assurance verification steps are generally called for at various steps during repair progress in addition to verification of the final product.

Since technical information has a direct relationship towards assuring the quality of work performed, the quality assurance division has the responsibility of operating a master technical library and monitoring of dispersed libraries within the various work centers. Dispersed libraries located within the work centers are necessary to place technical information in the hands of the user who is charged with compliance. The quality assurance division monitors the operation of these dispered libraries, providing new publications, revisions, cancellations, and such other information that may affect the publications held. A change entry certification form is utilized to ensure that all change and revision material is entered into the directives and manuals of the dispersed libraries within a reasonable time.

Since the responsibility area of the supervisor is the middle ground between management and men, it is incumbent upon him to initiate and administer a quality assurance program. His main objective is to improve the state of training of his men until their mental attitude is such that top quality workmanship becomes second nature. How successful he is in achieving this objective will be determined by his ability and insight in the following areas:

1. The assignment of the proper number of qualified men to do the jobs plus on-the-job trainees.

2. Making provisions for adequate on-the-job supervision and inspection.

3. Allowing adequate time to perform safe, high quality jobs.

4. Assuring himself that current directives and publications on safety and aircraft model concerned are available and complied with.

5. Monitoring the training program with respect to timeliness and completeness of coverage. Eliminating out-of-date training material promptly and introducing important new material as soon as possible after receipt without regard to lesson schedules.

These procedures should result in high quality workmanship by work center personnel and meeting of specifications and quality standards in the work.

Personnel to be designated as inspectors should possess the following attributes.

1. Should be experienced and fully knowledgeable within high technical rating.
2. Should possess the ability to research, read, and interpret drawings, schematics, technical manuals, and directives.
3. Should be able to write with clarity and technical accuracy.
4. Should be observant, alert, and inquiring with a record of excellence and stability in the performance of his duties.
5. Should be able to work with others and possess the personal desire and motivation to develop a greater knowledge of his technical speciality.
6. Should be a senior in his paygrade and in experience.

Each man designated as an inspector should receive an indoctrination on quality assurance objectives, policies, and procedures as provided in OPNAV Instruction 4790.2 (Series). The indoctrination requirement is directed toward developing an appreciation for the importance and necessity of an organized quality assurance effort on a continuing basis.

TRAINING OF INSPECTORS

Training of personnel involved in quality assurance and collateral duty inspection requires continuous training in weapon system familiarization, repair procedures, trouble-shooting techniques, inspection, testing, and quality assurance considerations specifically applicable to their areas of maintenance.

Quality assurance representatives verify the adequacy and accuracy of inspections performed by the collateral duty inspectors of the work center. Collateral duty inspectors are permanently assigned to the work center and, in addition to other assigned duties, they are assigned to inspect work accomplished by other personnel within the work center. Both the representatives and the inspectors are designated in writing by the commanding officer. Only those personnel designated in writing are authorized to sign as inspectors on maintenance forms or to certify in any way that a component or equipment is ready for issue or use. A sample inspector designation form is provided in OPNAV Instruction 4790.2. Copies of the form are kept in the quality assurance files and the division officer's files, with the original going in the man's service record.

QUALITY ASSURANCE AUDITS

An audit plan that encompasses all areas of work performed in the maintenance department is developed by the quality assurance officer and is utilized to audit each work center at least once quarterly. The audit plan is designed to evaluate the adequacy of technical documents, the quality of work being performed, and the validity of related maintenance and quality assurance inspection procedures.

Internally caused deficiencies are reported to the appropriate supervisor with requirements for corrective action.

Externally caused deficiencies are discussed with the work center concerned and a complete report is submitted to the maintenance officer with comments and recommendations for remedial or corrective action as required.

The person performing the audit will generally have prepared himself by having reviewed the appropriate section of the Quality Assurance chapter of OPNAV Instruction 4790.2 pertaining to the purpose and goals of the audits. The inspector should have researched various work center functions and conditions so that he has the necessary information required to perform a meaningful audit.

In all probability the inspector will have reviewed such areas as:

1. The work center's compliance with the precision measuring equipment (PME) program.

2. Participation in the UR program.

3. The message board to ensure that the supervisor has been reading it daily.

4. The previous audit.

Additionally he will be forearmed with the following information:

1. A list of the work center's outstanding job control numbers.

2. A list of publications checked out to the work center by the technical library.

3. A list of collateral duty inspectors assigned to the shop and the work shift to which they are assigned.

Figure 2-11 provides an example of a representative audit form utilized in one maintenance activity. The form shown is general in nature and could easily be expanded, as necessary, to include specific areas peculiar to a work center.

PLANNING FOR ADVANCED BASE OR FORWARD AREA OPERATIONS

A Chief Aviation Structural Mechanic H must be able to prepare for advanced base or forward area operations by estimating aircraft spare parts and supplies, equipment, and manpower requirements for aviation structural repair. In determining requirements for forward area or advanced base operations, it is necessary to consider the following:

1. Mission.

2. Environment.

3. Operating factors.

4. The availability of existing facilities.

A knowledge of the material and manpower requirements as listed in the Advanced Base Initial Outfitting Lists of Functional Components will be very helpful. The functional component is one of more than 300 standardized units of the system which the Navy has developed to enable it to build and operate its advanced bases in the least possible time and with a minimum expenditure of planning and logistic effort.

A functional component is a list of the requirements for the performance of a specific task at an advanced base, and consists of a carefully balanced combination of material, equipment, and/or personnel.

Each functional component is classified according to its primary function into i of 11 major groups, including aviation. Each major grouping is identified by letter designation and title; the functional components contained in each are identified by a combination letter, number, and title designation. The major group letter for aviation is H.

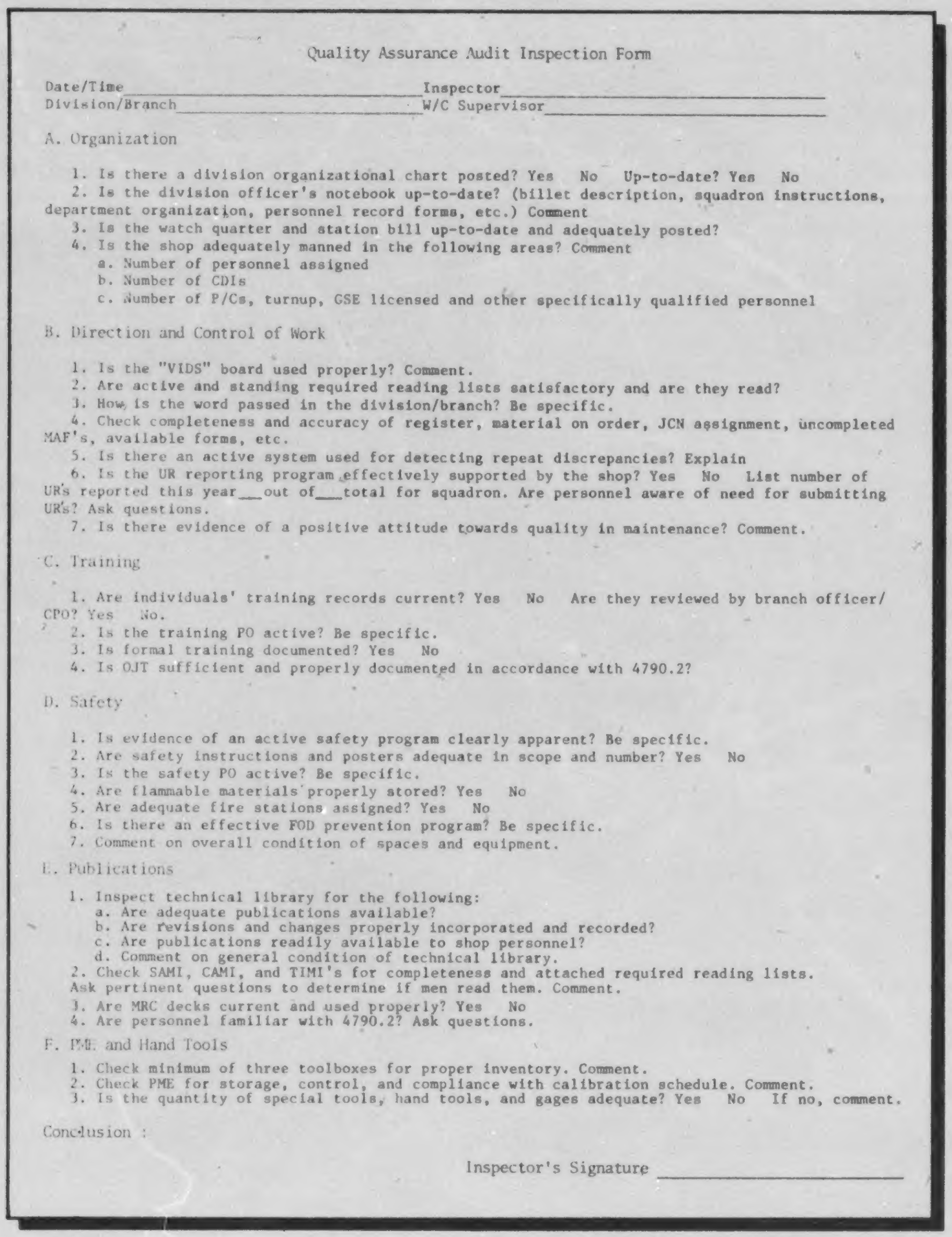
H components are designed to provide for maintenance, support, and operation of aircraft in an advanced area under combat conditions, and may be combined with other functional components to form several types of air stations.

Complete information and data are given in the abridged and the detailed outfitting lists for functional components.

It should be apparent to the AMH that the advanced base requirements may not be exactly as they appear in the Advanced Base Initial Outfitting Lists. In order to use these lists as guides, it will be necessary in most cases to alter or tailor them to fit the individual needs of the unit about to deploy.

Other necessary repair parts, supplies, and equipment may be determined from the outfitting and allowance lists for the aircraft or other weapon system to be supported.

It is quite likely that the AMHC will be required to advise the personnel office in making assignments of individuals to advanced base or forward area operating units. It would seem logical that the number of Aviation Structural Mechanics assigned to deploy be in the same ratio as the percentage of supported aircraft scheduled to deploy. This may be true if the proposed flight hours per aircraft of the detachment exactly equaled the planned utilization of the remaining aircraft and if there are no significant environmental problems to be overcome. The list of personnel assigned to



Quality Assurance Audit Inspection Form

Date/Time ______________________ Inspector ______________________
Division/Branch ______________________ W/C Supervisor ______________________

A. Organization

1. Is there a division organizational chart posted? Yes No Up-to-date? Yes No
2. Is the division officer's notebook up-to-date? (billet description, squadron instructions, department organization, personnel record forms, etc.) Comment
3. Is the watch quarter and station bill up-to-date and adequately posted?
4. Is the shop adequately manned in the following areas? Comment
    a. Number of personnel assigned
    b. Number of CDIs
    c. Number of P/Cs, turnup, GSE licensed and other specifically qualified personnel

B. Direction and Control of Work

1. Is the "VIDS" board used properly? Comment.
2. Are active and standing required reading lists satisfactory and are they read?
3. How is the word passed in the division/branch? Be specific.
4. Check completeness and accuracy of register, material on order, JCN assignment, uncompleted MAF's, available forms, etc.
5. Is there an active system used for detecting repeat discrepancies? Explain
6. Is the UR reporting program effectively supported by the shop? Yes No List number of UR's reported this year___out of___total for squadron. Are personnel aware of need for submitting UR's? Ask questions.
7. Is there evidence of a positive attitude towards quality in maintenance? Comment.

C. Training

1. Are individuals' training records current? Yes No Are they reviewed by branch officer/CPO? Yes No.
2. Is the training PO active? Be specific.
3. Is formal training documented? Yes No
4. Is OJT sufficient and properly documented in accordance with 4790.2?

D. Safety

1. Is evidence of an active safety program clearly apparent? Be specific.
2. Are safety instructions and posters adequate in scope and number? Yes No
3. Is the safety PO active? Be specific.
4. Are flammable materials properly stored? Yes No
5. Are adequate fire stations assigned? Yes No
6. Is there an effective FOD prevention program? Be specific.
7. Comment on overall condition of spaces and equipment.

E. Publications

1. Inspect technical library for the following:
    a. Are adequate publications available?
    b. Are revisions and changes properly incorporated and recorded?
    c. Are publications readily available to shop personnel?
    d. Comment on general condition of technical library.
2. Check SAMI, CAMI, and TIMI's for completeness and attached required reading lists. Ask pertinent questions to determine if men read them. Comment.
3. Are MRC decks current and used properly? Yes No
4. Are personnel familiar with 4790.2? Ask questions.

F. PME and Hand Tools

1. Check minimum of three toolboxes for proper inventory. Comment.
2. Check PME for storage, control, and compliance with calibration schedule. Comment.
3. Is the quantity of special tools, hand tools, and gages adequate? Yes No If no, comment.

Conclusion :

Inspector's Signature ______________________

214.3

Figure 2-11.—Typical quality assurance audit inspection form.

deploy should represent a cross section of the skill levels available unless special maintenance factors indicate otherwise. The selection of personnel should be made as objectively as possible so that the deployed unit may function efficiently without working a hardship on the home group.

TRAINING OF PERSONNEL

Training of personnel is a necessary function and one of the most important responsibilities of senior Aviation Structural Mechanics. A Chief Aviation Structural Mechanic H and, to some extent, a First Class will have regular and continuing responsibilities for the training of others. Specialized skills are required to maintain and operate the complex present day weapons systems and their related test equipment.

Navy training schools, factory training, and in-service training are available for the training of maintenance personnel. The class A and B schools provide the necessary prerequisites for the specialized supplementary training provided on specific aircraft, equipment, groups of related equipment, or specialized techniques (maintenance management) by the various NAMTRADETs.

Even if a supervisor is fortunate enough to have a group of men who are highly skilled and well trained, he will find that training is still necessary. For example, the training of strikers and lower rated men for advancement examinations is a continuing, never-ending process. The Navy rotation policy being what it is, the best men will eventually be transferred and replacements will be received aboard. The replacements will, in most instances, require training before they can be relied on to take their places as effective members of the shop organization. These and similar problems require the airframes supervisor to be well versed in the several aspects of training. He must be able to set up as well as conduct an effective inservice training program for assigned personnel.

ORGANIZING THE TRAINING PROGRAM

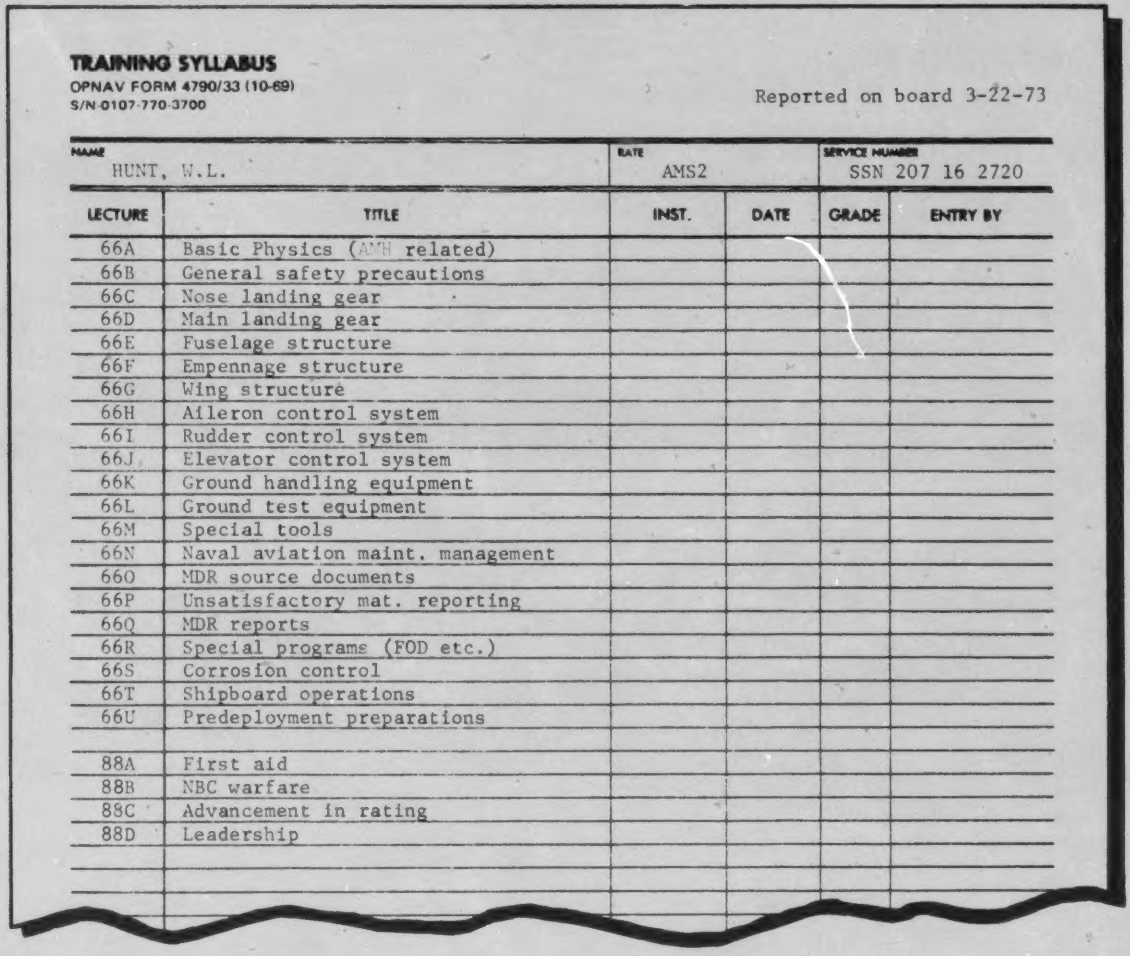
Organizing a training program involves such considerations as planning lessons and job plans, selecting and qualifying instructors, making arrangements for classroom space, phasing the training program with the scheduled workload, procuring visual and other training aids, and determining teaching methods for each lesson or lesson series.

The subject matter areas to be included in the training program are (1) material relating to maintenance of aircraft supported, (2) general material required by the men for advancement in rating examinations, and (3) material relating to safety. In most cases lessons will fall under more than one of the subject areas.

Once it has been determined what publications will adequately cover the subject areas, the material must be divided into lessons, and lesson guides prepared. The lesson guides for each lecture are prepared in accordance with the standard format provided in OPNAV Instruction 4790.2 (Series). The lectures are numbered to provide a means of recording each man's progress within his individual training folder. A training syllabus sheet, similar to the one illustrated in figure 2-12, is prepared for each man in the work center and provides a handy index to the state of training of the work center personnel as a whole.

Whether the supervisor teaches the lessons himself, or assigns other petty officers to conduct them depends on the state of training of his first and second class petty officers. A requirement for advancement for third class petty officers and nonrated personnel is satisfactory completion of the correspondence course based on *Military Requirements for Petty Officer 3 & 2*, NAVEDTRA 10056 (Series). This text book sets forth some of the basic principles of training in general and teaching in particular.

An advancement requirement for second and first class petty officers is satisfactory completion of the correspondence course based on *Military Requirements for Petty Officer*



TRAINING SYLLABUS
OPNAV FORM 4790/33 (10-69)
S/N-0107-770-3700

Reported on board 3-22-73

NAME HUNT, W.L.
RATE AMS2
SERVICE NUMBER SSN 207 16 2720

LECTURE	TITLE	INST.	DATE	GRADE	ENTRY BY
66A	Basic Physics (AMH related)				
66B	General safety precautions				
66C	Nose landing gear				
66D	Main landing gear				
66E	Fuselage structure				
66F	Empennage structure				
66G	Wing structure				
66H	Aileron control system				
66I	Rudder control system				
66J	Elevator control system				
66K	Ground handling equipment				
66L	Ground test equipment				
66M	Special tools				
66N	Naval aviation maint. management				
66O	MDR source documents				
66P	Unsatisfactory mat. reporting				
66Q	MDR reports				
66R	Special programs (FOD etc.)				
66S	Corrosion control				
66T	Shipboard operations				
66U	Predeployment preparations				
88A	First aid				
88B	NBC warfare				
88C	Advancement in rating				
88D	Leadership				

214.1

Figure 2-12.—Sample training syllabus sheet.

1 & C, NAVEDTRA 10057 (series). The latter text expands and amplifies training theory and introduces job analyses, training aids, and testing. For the first time in his career the prospective First Class Aviation Structural Mechanic H is required to demonstrate his ability to formally teach, use various training aids, and prepare and administer written tests. In order to demonstrate correct instructional techniques, the supervisor may elect to teach certain lessons himself or assign them to a competent instructor for the same purpose. Later he may assign less proficient petty officers as instructors so that they may acquire the experience necessary for completing their practical factors for advancement.

If at all possible, training sessions should be conducted at the same time of day and on a regular schedule. Training must be scheduled to encompass all working shifts so that all personnel are included in the overall training program. Factors to consider when scheduling lessons are usual flight schedule, meal hours, watches, availability of classroom, and aircraft inspection schedule.

Some lessons are better suited for one type of instructional technique than others. The type of presentation for each lesson should be planned in advance. This will also facilitate the rotation of the lessons among the petty officers who require experience in teaching.

The effectivity of aviation technical training is greatly enhanced by the use of training aids. The supervisor should always be on the alert for scrap material that can be converted to training aids with minimum expense. He must be aware of the existence of applicable training films and, if they are available, schedule them for showing in conjunction with specific lessons. The squadron or unit safety officer or station safety engineer may usually be depended on to supply training aids in support of shop safety presentations.

When planning a training program, the supervisor should decide where the classroom sessions should be conducted. The space selected should preferably be in a quiet area or at least one with a minimum of noisy distractions. The area should be large enough to accommodate the expected student load and be will lighted. Adequate ventilation will help keep the men awake and interested in the presentation. Convenience is another factor in the selection of classroom space. Some of the desirable space characteristics may, on occasion, have to be sacrificed in order to find a classroom nearer to the working area.

TRAINING PROCEDURES

Inservice training represents a major contribution to the Navy's overall training program. To satisfy the individual activity's particular requirements, the training program must include both lectures and practical training. In this respect, training procedures are of two general types–formal and informal.

Formal Inservice

Formal inservice training is conducted in the classroom through lectures, supplemented by required reading and implemented by the use of all available visual aids. A schedule of training is prepared and published by the maintenance administration officer. This schedule is usually prepared on a monthly basis and lists the subject of the lesson or its identifying syllabus number, the time that the training is to take place, the location of the classroom, the names of the men who are to attend, and the name of the instructor.

Lesson guides are prepared by designated officers, petty officers, and in some cases by Contractor Engineering Technical Services/Navy Engineering Technical Services personnel. The lesson guides should contain the lecture number, title, date prepared and by whom, objectives of the lesson, time normally required in presenting the lesson, list of instructional aids, list of references with which the instructor should become familiar before teaching the lesson, outline for presentation, summary of the lesson, and questions and answers to check for understanding.

When a petty officer has been assigned to instruct a given lesson, it is his responsibility to procure a copy of the lesson guide and from it prepare his personalized lesson plan. Since lesson plans are prepared by the individual instructor, they may differ slightly from instructor to instructor. They must cover the information outlined in the lesson guide. The quality of the lesson given will reflect the amount of preparation given by the instructor plus his experience and ability to instruct.

Informal Inservice

Informal training is the practical instruction of men in the performance of maintenance tasks by means of demonstration and imitation under personal supervision in the shop or on the operating line. Nearly every maintenance task that is undertaken presents an opportunity for on-the-job training. The experienced men of the work center are utilized as fully as possible in demonstrating and imparting their skills to the less experienced.

Under this system, the trainee has the opportunity to actually do the job under the supervision of an experienced petty officer. The only equipment necessary is the job itself. It is necessary, of course, that the instructor have an interest in the job and the skill to do it well. The striker or trainee will learn by seeing the job performed, and he will gain experience by having a chance to participate in the accomplishment of the job.

The nature of informal training makes regular scheduling impracticable. Actually, it is done at every opporutnity. A training syllabus is prepared under the guidance of the maintenance officer, with content and scope corresponding with practical factor requirements of the personnel. The degree of success in on-the-job training (OJT) depends on the degree of recognition by each individual of his responsibility to his outfit to impart his skill and knowledge to the man who is trying to learn.

TRAINING DOCUMENTATION AND RECORDKEEPING

Maintenance activities that are directed to account for production manhours should comply with the manhour accounting procedures outlined in OPNAV Instruction 4790.2 by submitting manhour accounting cards to reflect the accomplishment of formal inservice training. Procedures for submitting manhour accounting cards are provided in *Military Requirements for Petty Officer 3 & 2*, NAVEDTRA 10056 (Series), and OPNAV Instruction 4790.2.

The individual Training Syllabus Sheet provides a record of formal lectures attended by each man in the work center. A report of practical training (OJT) should be made to the division officer at regular intervals. This will indicate to the division officer that a man has fulfilled a satisfactory level of skill to justify completing of the various items listed on the individual's practical factors for advancement sheet. The formal training syllabus record and the record of practical training will indicate that required training has been completed in all areas or that a need for special training exists and further certifies when the individual may be considered qualified for advancement.

MAINTENANCE SAFETY

The Chief of Naval Operations at the direction of the Secretary of the Navy is assigned the responsibility for implementation, direction, and supervision of the Department of the Navy Safety Program. This assignment was made to coordinate the effort and provide positive overall supervision through the chain of command. In this respect, safety becomes an inherent responsibility of command. Command implementation comprises those functions associated with command in carrying out safety policies and directives, and in amplifying safety guidance where necessary. The objective of the safety program is to establish an effective, aggressive, and continuous accident prevention program with the goal of enhancing operational readiness by reducing deaths and injuries to personnel as well as losses and damage to all Navy material from accidental causes.

AVIATION SAFETY PROGRAM

The activity safety officer is required to provide safety education throughout the command as well as to ensure that safety standards and procedures are incorporated into all activity functions. Other equally important tasks include translating data concerning accidents and mishaps into useful and meaningful information for activity use, monitoring the existing environment for hazard potential, and keeping the activity advised in matters concerning safety and accident free operations.

The key to this program as with many other programs is effective communications at all levels of command. A variety of publications are afforded to the safety officer and key members in the safety program. The Naval Safety Center helps to promote safety in aviation and other areas of operation through various safety oriented publications. Most of the publications are automatically distributed to aviation squadrons, ships, staffs, and shore activities. Each publication is intended for a primary audience but, in general, can be useful source material for a complete safety program. A brief introduction to these publications is provided in the following paragraphs.

APPROACH MAGAZINE, the Naval Aviation Safety Review, is published monthly for the benefit of all levels of naval aviation. It contains articles on flight operations, flight surgeons' notes, maintenance commentaries, and short features with the purpose of presenting the most accurate information currently available on the subject of aviation accident prevention.

MECH, the Naval Aviation Maintenance Safety Review, is published quarterly and is directed at the enlisted aviation maintenance personnel. It presents the most accurate information available on maintenance-caused mishap prevention and general aviation ground safety directed at reducing maintenance errors and handling mishaps. Contents of MECH are intended to be informational and should not be considered as orders, regulations, or directives.

FATHOM is published quarterly and is of special interest to submariners and surface ship personnel. It does contain material of interest to all hands such as articles of general educational interest and statistics on accidents and incidents. It also provides recommendations for improving shipboard safety.

WEEKLY SUMMARY OF MAJOR AIRCRAFT ACCIDENTS contains safety discussions, accident briefs, statistics, and safety tips. It is provided primarily for command considerations.

SHIPS SAFETY BULLETIN is a monthly publication and is the counterpart of the Weekly Summary of Major Aircraft Accidents. It contains articles on current shipboard safety problems, trends, accident briefs, and statistics pertaining to ships safety.

EMERGENCY AIRBORNE ESCAPE SUMMARY is published annually to provide commands, operators, and other interested agencies with data compiled on ejections, bailouts, and ditchings of Navy and Marine aircraft.

LIFELINE, the Navy safety journal is published bimonthly. This publication emphasizes the human factors in accident prevention, occupational health and safety, industrial and fire safety, and safety and survival equipment. It presents the most accurate information currently available on the subject of environmental and occupational safety and is one of the means by which the Naval Safety Center provides the Navy with educational material necessary for pursuing a vigorous and effective command safety program.

The Safety Center also provides posters featuring the various aspects of operations at sea, in aviation, and ashore. They are available on request from the NAVSAFCEN. Articles for these publications are submitted by fleet activities and training commands. Personnel with safety related experiences that might benefit others should pass them along to the safety center for consideration. Most of these publications are intended for more than one reader, and the information contained in them should be appropriately disseminated.

The safety program established at the maintenance department/division level must be a primary concern of all hands. It requires active participation by all personnel on a day-to-day basis to obtain the desired results. The quality assurance division is assigned overall responsibility for the safety program at this level and establishes a coordinating group to assist in implementing the total safety plan of the activity. The quality assurance plan for the activity includes the safety program requirements. Lower level directives are prepared as necessary to ensure proper implementation throughout the department/division. Items given attention in the maintenance safety program include, but are not limited to, the following:

1. Dissemination of appropriate safety posters and literature.

2. Reporting of all accidents, incidents, and unsafe practices in the department.

3. Conducting of safety meetings within the department/division. The minutes of these meetings and pertinent agenda items should be published and made available to the maintenance supervisors concerned.

4. Participation in activity safety surveys as may be required by higher authority. Safety Review Checklists are available from the Naval Safety Center as an aid for conducting safety surveys.

Effectiveness and safety result from properly trained personnel using properly designed equipment in accordance with established procedures under competent and persistent supervision.

Aircraft maintenance is, to some extent, naturally hazardous due to the nature of the work, the equipment and tools involved, and the variety of materials required to perform many repairs and maintenance functions. Factors which can function to increase or decrease these hazards include the following:

1. The experience levels and mental attitudes of assigned personnel.

2. Tempo of operations combined with haste and inattentiveness.

3. Unnecessary risk or disregard of common safety practices.

4. Disregard or unawareness of technical and safety directives.

5. The quality or lack of supervision of the maintenance tasks.

6. The adequacy of indoctrination of all personnel regarding the potential hazards within the work area.

The primary function of naval aviation maintenance personnel is that of keeping aircraft in top operating condition with a resultant high degree of readiness for prompt and sustained combat operations. Temporary or permanent loss of personnel or equipment directly affects the combat readiness of the activity concerned.

Accident prevention is affected more by the quality of professional competence demonstrated by key individuals than by any other consideration. The close personal attention of maintenance supervisors is required.

The concept of aircraft maintenance safety should extend beyond concern for injury to personnel and damage to equipment and aircraft. Safe work habits go hand-in-hand with flying safety. Tools left in aircraft, improper torquing of fasteners, and poor housekeeping around aircraft can cause conditions which may claim the lives of flying personnel as well as cause strike damage to aircraft. Safety on the ground is equally as important as safety in the air.

A recent type commander letter states in part, "While the increased complexity of our modern aircraft is a factor, it is noted that a large number of maintenance-error-caused accidents and incidents are due, not to complexity of equipment, but to lack of supervision and technical knowledge. Many mistakes are simple ones in routine maintenance."

Safety in aircraft maintenance depends largely upon the supervisory personnel. The standards of quality which they establish are directly reflected in the quality of the aircraft maintenance. The primary duty of the senior petty officers is to supervise and instruct others rather than to become totally engrossed in actual production. Attempts to perform both functions invariably result in inadequate supervision and greater chance of error. Supervisors must exercise mature judgment when assigning personnel to maintenance jobs. Consideration must be given to each man's experience, training, and ability.

Sometimes overlooked in a maintenance program are the considerations generally grouped under the term "human factors." These factors are important in that they determine if an individual is ready and physically able to do work safely and with quality. Supervisory personnel should be constantly aware of conditions such as general health, physical and mental fatigue, unit and individual morale, training and experience levels of personnel, and other conditions which can contribute in varying degrees to unsafe work. Not only is it important that proper tools and protective clothing and equipment are available for use, but also the insistence by maintenance supervisors that they are used is of increasing important with modern high performance aircraft. For example, maintenance personnel are sometimes negligent in the wearing of protective hearing devices in high noise areas.

Technical knowledge also plays a large part in a good maintenance safety program. The complexity of our modern equipment demands the attention of well-informed and expert maintenance personnel; otherwise, our weapons systems cannot be operated and maintained. Technical knowledge is a function of education and training which, incidentally, does not end with graduation from Class A school. Graduation is only the beginning. Any AMH worthy of the rating is continually training and learning through self-study and application and through a personal desire for proficiency and self-betterment. But technical knowledge by itself is not sufficient unless it is coupled with an old-fashioned craftsmanship that receives gratification and keen satisfaction in doing any job well. The AMH who wishes to contribute to safety and reliability improvement must know his job and must develop professional pride in the quality of his work.

It is a continuing duty of every person connected with aircraft maintenance to try to discover and eliminate unsafe work practices. Accidents which are caused by such practices may not take place until a much later date, and their severity cannot be predicted. The consequences may range from simple material failure to a major accident resulting in serious injuries or fatalities.

There are several areas in which the supervisor can effectively work to minimize accidents incident to aircraft maintenance. The organization and administration of an active and continuous program of accident prevention with provisions for inspection of work areas, tools, and equipment; correct interpretation and dissemination of safety directives and precautions; and energetic and imaginative enforcement of them is all important.

ORGANIZATION AND ADMINISTRATION OF AN ACTIVE PROGRAM

It is the responsibility of all supervisory personnel to ensure that their subordinates are instructed in and carry out the applicable safety precautions for their area of work. Each individual is held responsible for knowing, understanding, and observing all safety precautions applicable to his work and work areas. The individual is additionally charged with the following responsibilities:

1. The individual should report to work reasonably rested and emotionally prepared to perform the tasks at hand.
2. He should exercise normal prudence in all his functions, commensurate with the work at hand.
3. He should report all unsafe conditions regarding equipment and materials and any unusual or developing hazards to his immediate supervisor for appropriate action.
4. He should warn others whom he believes to be endangered by known or potential hazards and of their failure to observe safety precautions.
5. He should report to his supervisor any accident, incident, injury, or evidence of potential hazard occurring in the course of work.
6. He should wear or use the protective clothing and/or equipment of the type approved, required, and provided for the safe performance of his work.
7. He should report for work suitably attired for his assigned tasks. For example, wear eye correction, hearing aid, foot protection, style of clothing, hair style, beard, etc., as applicable, that will not present a hazard.

The safety program must in accordance with local instructions and instructions provided in OPNAV Instruction 4790.2 for the maintenance department/division safety program. The Navy Aircraft Accident, Incident, and Ground Accident Reporting Procedures provided in OPNAV Instruction 3750.6 (Series) require maintenance personnel participation in investigating, reporting, and preventing aircraft accidents/incidents.

NAVMAT Publication P-5100, Safety Precautions for Shore Activities, contains precautions that cover almost all aspects of maintenance safety that are to be implemented by maintenance personnel. Mandatory precautions in this manual are characterized by use of the words shall, must, and prohibited. Recommended or advisory precautions are indicated by use of the words should, will, and may. The precautions are of necessity basic and general in nature and are not inclusive of all conceivable operations and functions involved in the large variety of Navy day-to-day activites. Reference is made from time to time to other publications for detailed safety information applicable to a specific condition or hazard. A lack of documented hazard with accompanying precautions is not an indication of their nonexistence or unimportance. Maintenance personnel must display continuous cooperation and vigilance in seeing that all operating procedures and work methods do not unnecessarily expose personnel to injury or property to loss or damage.

The NATOPS program provides complete and detailed guidance on procedures and precautions to be followed when operating naval aircraft. General guidance of concern to supervising petty officers may be found in the NATOPS Manual *General Flight and Operating Instructions* and the CVA/CVS NATOPS Manual. Ground and flight procedures for individual aircraft are contained in the NATOPS Manual for each specific aircraft.

The ground procedures will in most cases parallel those found in the General Information and Servicing volume of the Maintenance Instructions Manual for the specific aircraft concerned.

Instructions in appropriate safety precautions are required to be given and positive action must be taken in the case of willful violations.

The safety program will generally involve three areas of attention–the posting of the most important safety precautions in appropriate places, the incorporation of safety lessons in the formal training program, and frequent checks for understanding and compliance during the day-to-day supervision of work.

Fixed posters and signs must be placed in locations where personnel are most likely to see them and where they will provide the maximum impact. They should be relevant to activities engaged in by personnel located in the space where they are displayed and removed or rotated to enhance their effectiveness. Visual information should be presented in a positive manner so that it will impart appropriate precautionary measures without instilling fear. Appropriate safety posters may be obtained from the activity safety officer.

Posted safety precautions are more effective if they are easily complied with. For example, a sign on a tool grinder reads "goggles required," so one or more pairs of safety goggles should be hanging within reach at the machine. Similarly, the protective clothing poster in the AMH work center should be backed up with readily available coveralls, gloves, shields, etc.

The formal safety training sessions should utilize films, books, visual aids, or any other suitable technical material. The men should be told more than just what or what not to do. Each safety subject should be explained in detail. The results of unsafe acts are usually the most dramatic and easiest remembered. Causes of accidents and contributing factors should be reviewed and analyzed. Many good ideas for accident prevention have been developed in training sessions.

An extensive series of lessons may be developed over a period of time as latent hazards are recognized. This will aid in keeping the sessions interesting while avoiding too frequent repetition.

It may be well to mention the new man in the work center at this point. A separate safety indoctrination lesson which covers all the major hazards of the work center should be given the new man as soon as he reports for work. No supervisor with an effective safety program and an excellent work center safety record wants to take the chance that the new man will be injured before attending the complete series of safety lessons.

In the third area of safety program administration–followup–the supervisor will have one or more key members of the work center who attend the quality assurance safety meetings. These members will provide inputs regarding safety violations and potential hazards that should be advertised and disseminate information discussed during meetings to all personnel in their respective work area. These members as well as supervisors provide a definitive communication link in pointing out peculiar activity hazards and current violations and can take immediate action to remedy such situations. Subordinate petty officers must assist in monitoring the program on a continuous basis. Also included in the followup area is a responsibility of the supervsior to inquire as quickly and thoroughly as possible into circumstances of accidents and reports of unsafe practices and the taking of action and/or making of recommendations.

Interpretation of Safety Directives and Precautions

The safety precautions contains in Safety Precautions for Shore Activities are designed to cover usual conditions ashore. Commanding officers and others in authority are authorized to issue special precautions to their commands to cover local conditions and unusual circumstances. The supervisor will have to apply both sets of rules in the administration of his work center safety program.

Safety directives and precautions should be followed to the letter in their specific application. Should any occasion arise in which any doubt exists as to the application of a particular directive or precaution, the measures to be taken are those which will achieve maximum safety.

When new safety posters or precautions are posted, it is the responsibility of the supervisor to correctly interpret their application to his men. In this way he will be able to achieve a unity of thought and action in the observance of the required safety rule.

The organization's safety officer is available to assist in interpreting and suggesting ways of implementing various safety directives and precautions. Current directives require that a safety officer or safety engineer be assigned as head of the safety department, division, branch, or section, whichever is applicable, at all shore stations.

In most instances the hazards involved and the applicable precautions for a given type of work are the same whether the work is done afloat or ashore. However, the safety program must account for inherent dangers and provide precautions necessary for afloat operations that are not present ashore. An example of this is a hazard peculiar to flight deck operations.

Inspection of Work Areas, Tools, and Equipment

Most accidents which occur in noncombat operations can be prevented if the full cooperation of personnel is gained and vigilance is exercised to eliminate unsafe acts. The airframes supervisor should diligently inspect work areas, tools, and equipment to detect potentially hazardous and unsafe conditions and take appropriate corrective action. The AMH may be working in the shop, in the hangar, or on the line, and all these areas should be included in the supervisor's inspection. He should check for explosion or inhalation hazards due to improper ventilation of working spaces, or careless handling of materials.

Fire hazards present another serious problem. "No Smoking" rules should be strictly enforced. Ground wires should be installed on every aircraft during maintenance to eliminate dangerous static electrical buildups. Spilled oil, grease, and chemicals should be wiped up promptly, and all rags used should be disposed of in covered metal containers.

Handtools should be in good shape, of the proper type, and used only for the purpose for which they were designed.

Ensure that equipment is operated only by qualified personnel, and that all safety devices and guards are installed and in good condition. The equipment should also be inspected for broken or damaged components. Check to see that periodic maintenance, servicing, and/or calibration are up-to-date for those equipments requiring it. Details on the Air Systems Command Calibration Program and amplifying information on other selected programs are provided in OPNAV Instruction 4790.2.

Weapons System Emergency Procedures

As previously stated, safety precautions peculiar to a specific aircraft are covered to a large extent in the General Information volume of the Maintenance Instructions Manual for that aircraft. The emergency procedures section of this manual is a most useful aid when producing safety training lectures for formal presentation. While it pertains primarily to line personnel, crash rescue personnel, and plane captains, the information could prove invaluable for that moment when a tailpipe fire, brake fire, nose gear collapse, or similar incident occurs in the absence of personnel trained to handle such emergencies and immediate action is required. As the senior person present, you would be expected to take charge and initiate this action.

The warnings and precautions dispersed throughout the various maintenance manuals and included in most other directives must be adhered to. Changes or revisions to manuals should be screened upon receipt for new procedures, warnings, precautions, etc., that may affect your area of work and that may require amplification or clarification.

A qualified AMH should also give all maintenance personnel an indoctrination regarding the hazards associated with the aircraft's ejection seats, canopy operation, and any other hazards associated with occupancy of the cockpit.

Ship Predeployment Indoctrination

Many times in the past, squadrons, well prepared concerning hazards associated with operating aircraft ashore, deployed to a ship with little or no indoctrination being provided with regard to the shipboard operating environment.

The work center supervsior should ensure that such indoctrination is accomplished well in advance of any personnel going to the ship for carrier qualification or extended deployments. The following paragraphs provide coverage on areas that have frequently been neglected.

Personnel should learn several ways to proceed from work spaces, berthing compartments, and messing compartments to a weather deck or source of fresh air. During fires and subsequent damage control procedures, personnel could encounter heavy smoke concentrations and complete darkness. Failure to know at least one or more escape routes that can be executed in the dark could be fatal.

When the ship is underway, personnel who are not specificially required to be on the flight deck must stay off it. When air operations are in progress, personnel required on the flight deck must be in a complete flight deck uniform. A complete uniform consists of an appropriate colored, long sleeve jersey and safety clamshell helmet, life vest, survival flashlight and whistle, flight deck/safety toe shoes, and when feasible, gloves. The survival flashlight should be checked daily and the life vest inflated at least once a week (orally) to check for leakage.

Personnel should be familiar with the various ship conditions and drill procedures and participate to the maximum extent authorized. During General Quarters (GQ) personnel should proceed to their assigned station at a fast pace; however, running is not recommended because of the possibility of striking hatch combings, knocking down of other personnel, and other hazards related to excessive speed.

All personnel in the activity must undergo refresher shipboard firefighting courses prior to deployment.

New personnel reporting to an activity already deployed should be given an indoctrination immediately. Such personnel become easily confused when attempting to find their way and are very prone to wandering where they do not belong. Allow one of the man's new shipmates to show him around so that he may become acquainted with his new surroundings in a safe manner.

CHAPTER 3

AVIATION SUPPLY

A Chief or First Class Aviation Structural Mechanic H, especially if in a supervisory billet, will find himself increasingly involved in the details of supporting the AMH on the job. One of these areas is in the field of aviation supply.

Aviation supply personnel are vital members of the aircraft maintenance team; and the AMH, as well as personnel in the other aviation maintenance ratings, must work in close harmony with them if successful teamwork is to be achieved. The team must work so that a flow of parts is maintained from the manufacturer to the AMH on the job–quite possibly an AMH doing repair work on the other side of the world. A correct concept of supply's relationship to the entire organization is essential in the supervision of aircraft maintenance functions.

ORGANIZATION AND FUNCTION OF NAVAL SUPPLY

The command exercising management control over the policies and procedures of the aviation supply organization is the Naval Supply Systems Command. The Commander of the Naval Supply Systems Command is usually a rear admiral. He works with the delegated authority of the Secretary of the Navy, and all policies and procedures of the aviation supply organization emanating from him have the full force and effect of SecNav orders.

To better understand the relationship of the Naval Supply Systems Command to the aviation supply system, it might be well to quickly review the development of the Navy supply system.

Prior to 1842, the commanding officers of ships and stations were responsible for the procurement of their own supplies. They were furnished funds for this purpose by the Navy Department and were required to account for all expenditures.

In 1842 Congress approved the establishment of a Bureau of the Navy to take cognizance over all matters of naval supply. The primary responsibilities of this infant supply bureau were the procurement, maintenance of custody, and issuance of naval material. They are the primary responsibilities of the Naval Supply Systems Command today.

By 1917 the Naval Aircraft Factory (NAF) in Philadelphia had come into existence and was assigned responsibility for the procuring of aircraft and spare parts.

In 1921 the Bureau of Aeronautics (Bu Aer) came into being and assumed the responsibility of procuring aircraft and aircraft engines. The responsibility for procuring spare parts and other aeronautical material remained with NAF, which until 1941 was the aviation supply center of the Navy.

The Aviation Supply Office (ASO) was established in 1941 under the technical control of BuAer and the management control of the Bureau of Supplies and Accounts. The function of ASO was the procurement, custody, and issuance of aeronautical spare parts and technical material. This is essentially the function of ASO today under the technical control of the Naval Air Systems Command. Management control of ASO is exercised by the Naval Supply Systems Command.

RESPONSIBILITIES OF THE NAVAL SUPPLY SYSTEMS COMMAND

The general functions of the Naval Supply Systems Command include many that are not related to aircraft maintenance, and not of primary interest to AM personnel. Listed below are some of the more important general functions of the Naval Supply Systems Command:

1. Supervises the procurement, receipt, custody, warehousing, and issuance of Navy supplies and materials, exclusive of ammunition, projectiles, mines, explosives, and medical supplies.
2. Supervises and directs the operation of the supply phases of the Navy supply system and administers the redistribution program of excess personal property within the Department of Defense and the sale of Navy surplus property.
3. Authorizes and supervises the transportation of Navy property.
4. Prepares budget estimates and administers funds for the supply distribution system.
5. Coordinates the compilation and arranges for the printing of the Catalogs of Navy Material.

Some additional functions of the Navy Supply Systems Command that are of interest to AM personnel are the general functions of ASO. These include the following:

1. Responsibility for overall determination of requirements, procurement, and distribution of standard aeronautical materials. (Certain materials excepted; such as complete aircraft and engines, complete electronic equipment, major photo equipment, nonstandard and experimental aerological equipment, and items of naval weapons ordnance equipment.)
2. Maintenance of a complete file of ASO and Naval Air Systems Command contracts, letters of intent, amendments, extensions, and change orders, and distribution of all necessary copies of documents to Navy field activities.
3. Stock control of aeronautical materials at all aviation supply facilities, including control of packing, preservation and distribution of material under ASO cognizance to, from, and between aviation supply facilities and major supply points.
4. Maintenance of complete records of material on order and followup procedure necessary to effect timely deliveries for all material under ASO cognizance.
5. Determination and disposition of obsolete and excess aeronautical material under NavAirSysCom cognizance.
6. Preparation and distribution of the Navy Stock List of ASO, including interchangeability data.
7. Compilation and distribution of some allowance lists subject to approval by NavAirSysCom.
8. Followup on delivery, stock recording, reallocating as necessary, and distributing change material promulgated by NavAirSysCom.
9. Maintenance of a representative at each aircraft manufacturer's plant who keeps ASO fully informed, as requested, as to all changes which affect spare parts under procurement.
10. Establishment of an inspection service which inspects aviation supply activities within established naval districts.

APPROPRIATIONS

At one time or another, almost everyone has had the frustrating experience of not being able to draw from supply some item needed immediately; the usual reason given being, "we do not have any money left." It takes only a short time to realize that the Navy does not operate with unlimited funds. This section and the following section, titled, "Operating Budgets," are presented to further an understanding of the system whereby funds are made available at the user activity level for operating expenses.

An estimate of the amount of money required for the operation of the Defense Department during a given fiscal year is prepared by Department of Defense fiscal experts well in advance of the beginning of the fiscal year. The Congress studies the proposed budget in the light of world affairs, the current domestic economy, and such other considerations as they see fit, then acts upon it. Congress may increase the amount requested, decrease it, or pass it as is. After presidential action is completed, the money is made available to the Department of Defense to be spent during a specified year. This is known as an "annual" or "one-year" appropriation.

Another form of appropriation is the "multiple-year" appropriation for projects which will be completed in a predictable length of time. An example of the use of this type of appropriation is the money appropriated to cover the expenses of the NROTC college program for the next 4 years.

The appropriation by which the AM is most affected is the "current-year" appropriation. After the appropriation or expenditure authorization is received in the Department of Defense, it is prorated among the services as a percentage of their previously submitted budget estimates. The Navy's share is prorated among the various systems commands and bureaus in essentially the same manner; that is, as a percentage of their estimated requirements for the coming fiscal year. The money to be spent for naval aviation is made available to NavAirSysCom. Here, part of the money is allocated to ASO for the purchase of aircraft spare parts and related equipment in quantities which past usage data has indicated will probably be sufficient for the coming year. These spare parts are furnished to the operating activities at no cost, since their usage has been anticipated and the items paid for in advance. The account from which money was spent to buy these items is known as the Appropriation Purchase Account (APA). Material received in the user activities from this account is known as APA material.

Another part of NavAirSysCom funds is made available to the operating activities in the form of operating budgets.

OPERATING BUDGETS

Budgets concerning naval aviation are authorizations by the Chief of Naval Operations to the user activities to spend a certain amount of money during a given length of time for specified purposes. User activities are shore commands which operate aircraft, and the major air type commanders. Major air type commanders are Commander, Naval Air Force, Atlantic (ComNavAirLant); Commander, Naval Air Force, Pacific (ComNavAirPac); Chief of Naval Air Training (CNATra); and Chief of Naval Air Reserve (CNARES). Operating funds for squadrons and units are apportioned to them by their type commander as an Operating Target (OPTAR). Routine nonaviation expenses for operating squadrons and units are absorbed by the ship or station to which assigned.

Operating Targets (OPTAR)

Funds to finance the operation of aircraft are allotted by the NavAirSysCom to the air type commanders. An OPTAR is a planned estimate which the air type commander allocates for the financing of aircraft operating costs during a given period of time. OPTARs are issued on a quarterly basis, and unused funds from the previously issued OPTAR revert to the control of the type commander as each new OPTAR is authorized. Type commanders provide OPTARs to squadrons, units, and ships under their operational control, whether or not the user activity is based ashore.

There are several different types of OPTARs issued by air type commanders for aviation purposes. Two that are of interest to AM personnel are FLIGHT OPERATIONS and AIRCRAFT MAINTENANCE FUNDS. These are discussed in the following paragraphs.

FLIGHT OPERATION FUNDS.–Funds which are used primarily for the purpose of financing actual flight operations; therefore, they have application at the organizational level. These funds finance the following:

1. Aviation fuels and lubricants consumed in aircraft.
2. Liquid and gaseous breathing oxygen and nitrogen.
3. Aerial film for use in aircraft cameras.
4. Flight clothing and operational equipment authorized in NavAirSysCom Allowance List (NavAir 00-35QH-2).
5. Flight deck/safety shoes.
6. Squadron administrative consumable office supplies.
7. Unit identification marks (shoulder patches) for initial issue to newly reported personnel.
8. Material and services required when located at an activity without Navy or Marine Corps intermediate maintenance capability.

AIRCRAFT MAINTENANCE FUNDS.–Funds which are provided to organizational and intermediate maintenance activities to finance the cost of various supplies and materials consumed in the performance of aviation maintenance. These funds finance the following:

1. Repair parts, common hardware, lubricants, cleaning agents, cutting compounds, metals, and other materials incorporated into or expended in the performance of aviation maintenance of aircraft, engines, aeronautical components and subassemblies, and Navy maintenance of aviation maintenance support equipment.

2. Fuels and lubricants consumed by aircraft engines in the performance of complete section repairs.

3. Pre-expended, consumable maintenance materials.

4. Replacement of expendable or consumable allowance list items with material accountability codes B and C. (Allowance list and material accountability codes are discussed later in this chapter.)

MATERIAL IDENTIFICATION

As aviation maintenance personnel, we work closely with the aviation storekeepers in keeping aircraft in an "up" status. In order to obtain replacement parts as rapidly as possible, we must know how to determine the source of supply of different items. For example, we may waste many hours trying to find out that the item is to be manufactured within our own activity. Also, it is important to know the correct stock number and cognizance symbols used to requisition items from supply.

The cataloging system developed by the Department of Defense is such that it identifies with one name and stock number any item of supply that is carried in any or all government agencies. In the procurement of material it is normally necessary to identify your material requirement in the medium understandable to the supply system.

NATIONAL STOCK NUMBERING SYSTEM

Prior to 1952, each of the services had its own numbering system for identifying, cataloging, stocking, and issuing items of military supply. It was not unheard of that one service would be negotiating on the open market for an item that was held in surplus by another service under its own stock number. This caused duplication and waste. There was no cross-reference system whereby an agency could determine if its excess material was the same as that which was in short supply in another agency. This confusion resulted in the passage of the Defense Cataloging Standardization Act.

The implementation of the Defense Cataloging Standardization Act has resulted in a reduction of item duplication between the services by providing for one National Stock Number (NSN) for each item, regardless of the use of the item or the using activity.

The National Stock Numbering System was intended to create and improve standardization of items of military supply in servicewide use and reduce excess inventories which, for the most part, were caused by lack of standardization. Also, the reduction of excess inventories eliminates much financial loss due to material obsolescence.

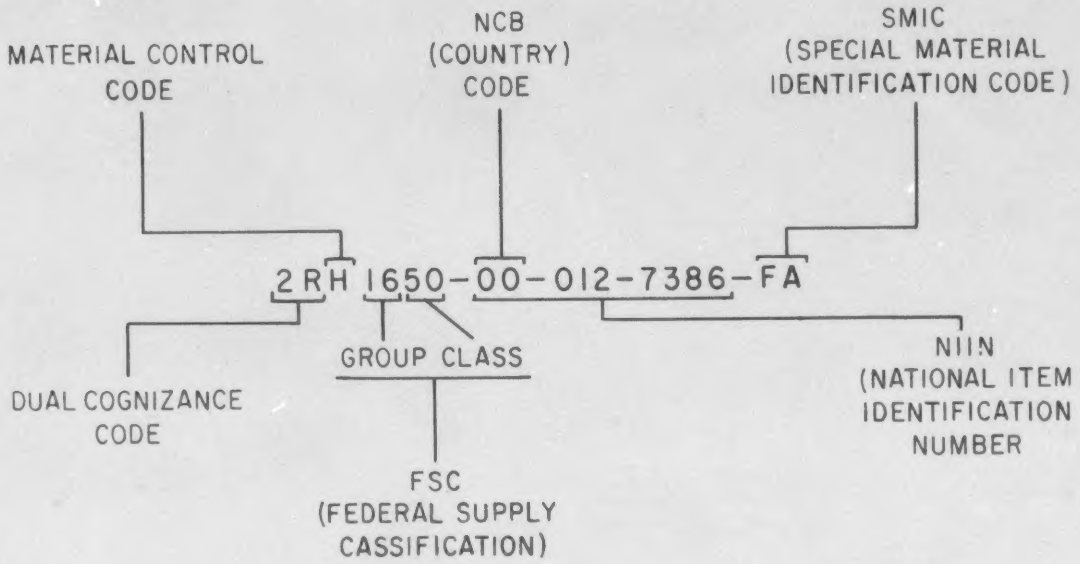
NOTE: While reference in this chapter is made only to the military application, it should be noted that the National Stock Numbering System is the prime numbering system for all Federal agencies.

Types of Stock Numbers

In the Navy, ASO uses National Stock numbers with prefixes composed of 1, 2, or 3 symbols, and suffixes composed of 2 characters which may be all letters or a combination of letters and numbers. When the prefixes and suffixes are used, the National Stock Number becomes a Navy Coded National Number. See Table 3-1.

When the first prefix symbol is used, it designates the command or office having control

Table 3-1.—Breakdown of a Navy Coded National Stock Number


MATERIAL CONTROL CODE
NCB (COUNTRY) CODE
SMIC (SPECIAL MATERIAL IDENTIFICATION CODE)
2RH 1650-00-012-7386-FA
DUAL COGNIZANCE CODE
GROUP CLASS
FSC (FEDERAL SUPPLY CASSIFICATION)
NIIN (NATIONAL ITEM IDENTIFICATION NUMBER

216.235

or cognizance of a particular item. Some of the more common cognizance symbols, together with the type material controlled and the cognizant command or office, are listed in table 3-2.

Many variations of coded stock numbers will be encountered in field maintenance work. These variations indicate material management responsibilities for the item; flag certain items as recoverable, consumable, high value, etc.; and identify the condition of the material if it is not ready for issue.

Because the variety of codes is so extensive and the trend to single service management of items has caused so many changes in recent years, a list of codes that might be prefixed or suffixed to a stock number would not be appropriate for this manual. The primary things to keep in mind are that the basic stock number, consisting of three groups of numerals, identifies the item from a technical point of view and that the other codes identify material management characteristics.

Cognizance Symbol

A cognizance symbol consists of a 2-character code prefixed to a national stock number to identify and designate the systems command, office, agency, or Navy inventory manager that exercises management control over specific categories of material. The first digit of the cognizance symbol also conveys certain accounting information to the supply system. Generally, odd numbers indicate that the material is carried in the Navy Stock Account (NSA), while even numbers indicate that it is carried in the Appropriation Purchase Account (APA).

Table 3-2.—Cognizance symbols

Cognizance symbol	Cognizant inventory manager	Stores account	Technical responsibility	Definition
0I	Naval Publications and Forms Center, Philadelphia	None	Navy Publications and Printing Service	Publications
1I	Naval Publications and Forms Center, Philadelphia	NSA	Navy Publications and Printing Service	Forms
1R	Navy Aviation Supply Office	NSA	Naval Air Systems Command	Aeronautical, photographic, and meteorological material (consumable or expense type material)
1W	Navy Fuel Supply Office	NSA	Naval Supply Systems Command	Bulk and drummed liquid petroleum fuels, bulk lubricating oils, bulk drycleaning solvents, calibrating fluids and corrosion preventives, new and used drums, and miscellaneous petroleum items
2R	Navy Aviation Supply Office	APA	Naval Air Systems Command	Aeronautical, photographic, and meteorological material (repairable or investment type material)
2V	Naval Air Systems Command	APA	Naval Air Systems Command	Photographic, meteorological, and aeronautical support equipment
8R	Naval Air Systems Command	APA	Naval Air Systems Command	Major aeronautical systems and equipment
9Z	Navy Fleet Material Support Office	NSA	Various bureaus and commands	Navy owned stocks of defense industrial material

The Navy Stock Account is an inventory account and integral part of the Navy Stock Fund. This fund exists to provide the necessary capital to finance the purchase of material used by the Navy. Requisitions for NSA type materials are charged against the activities OPTARs and credited to the Navy Stock Fund, making it a revolving fund. The value of the fund is reviewed annually by congress and adjusted to meet current requirements.

The Appropriation Purchase Account is a stores account which reflects the value of materials purchased by a systems command, such as NavAir, and charged to an appropriation. When such material is issued from stock for use, the account is not reimbursed as it was with NSA material.

The cognizant symbol 2R depicted in table 3-2 designates the item of supply as being APA material and under the inventory control of the Aviation Supply Office (ASO). Although the cognizance symbol officially consists of two digits, it will be observed that some publications and requisitioning procedures frequently drop the first digit for APA material, thus 2R is referred to as R, etc.

Table 3-2 lists some of the more common cognizance symbols, with the type material controlled and inventory manager.

Material Control Codes

Material control codes divide inventories into segments reflecting similar demand, repairability, or other characteristics. For example, some material control codes reflect either fast- or slow-moving demand characteristics, while others denote whether the item is to be repaired at the intermediate or depot level of maintenance. Management techniques peculiar to various items of material can be easily recognized at all levels of responsibility by this code. In the preceding stock number example, material control code H designates the item as repairable, subject to scheduled overhaul at designated Navy rework facilities or commercial overhaul. All defective repairable material must be returned to supply for subsequent overhaul upon receipt of a replacement item. Some material control codes used with aeronautical material are listed in table 3-3.

Material Condition Codes

Material condition codes classify material in terms of readiness for issue and use, or identify action under way to change the status of material. For example, one material condition code is used to indicate that a particular item is serviceable and ready for issue. If, after issue from the supply system and through use this item becomes unserviceable, its code would be changed to reflect the requirement for repair or overhaul. Naturally, upon completion of rework or repair, the material condition code would be changed to show that the item was once again serviceable and ready for issue. There are presently 13 different condition codes, letters A through N (less I), which may be assigned to Navy material. Since these codes apply to specific quantities of material, they do not appear in stock catalogs.

National Stock Number (NSN)

The national stock number consists of the applicable four-digit classification code number from the federal supply classification plus a hyphen and the applicable seven-digit national item identification number (NIIN).

FEDERAL SUPPLY CLASSIFICATION.—The federal supply classification (FSC) is a four-digit numerical code which comprises the first four digits of the NSN. It is used to identify stock items by commodity or descriptive category. The first two digits denote the group or major division of commodities. There are potentially 99 FSC groups. Many groups are unassigned. The second two digits denote the class or subdivision of commodities within a group. Table 3-4 lists some FSC groups of concern to the AM. These groups will be encountered in requisitioning aviation materials, administrative supplies, and general shop maintenance materials. Knowing the FSC group will occasionally prove beneficial

Table 3-3.–Material control codes

Code	Definition
A	Field activity control–Items on which continuous centralized item inventory is not exercised.
D	Repairable locally–Capable of being repaired by using activities or their immediate supporting activity.
F	Fast–High system quantity demand.
G	HIVAC Repairables with unit price of $1,000 or more–Material subject to special transaction reporting from acquisition to final disposition.
H	Repairables other than G, X, or Q–Capable of being repaired by depot maintenance activities.
J	HIVAC Consumables with unit price of $1,000 or more–Material subject to special transaction reporting from acquisition to final disposition.
M	Medium–Medium system quantity demand.
Q	Repairable high value items with unit price of less than $1,000.
R	Insurance–Essential item with unpredictable demand, long lead time, and difficult to procure.
S	Slow–Low system quantity demand.
X	Special Program–Currently assigned to all accountable cognizance 2R and 2V aircraft maintenance support equipment.

in locating information required to submit requests for material.

The cataloging Handbook H2-3 provides a complete alphabetical index for description to federal supply classification number. Figure 3-1 illustrates a page from this handbook.

The following are examples of FSC four-digit classes showing group and class breakdown:

GROUP 16 Aircraft components and accessories	1610	Aircraft propellers
	1620	Aircraft landing gear components
	1630	Aircraft wheels and brake systems

GROUP 53 Hardware and abrasives	5305	Screws
	5306	Bolts
	5307	Studs
	5310	Nuts and washers
	5320	Rivets

The Defense Supply Agency Cataloging Handbooks, H2-1, H2-2, and H2-3 contain a complete listing of assigned federal supply classification classes.

NATIONAL ITEM IDENTIFICATION NUMBER.–The NIIN is a seven-digit number which identifies each item of supply used by the Department of Defense (DOD). The NIIN indexes or relates to identification data

Table 3-4.—FSC groups

Group	Title
15	Aircraft and airframe structural components.
16	Aircraft components and accessories.
17	Aircraft launching, landing, and ground handling equipment.
26	Tires and tubes.
31	Bearings.
34	Metal working machinery.
40	Rope, cable, chain, and fittings.
42	Firefighting, rescue, and safety equipment.
43	Pumps and compressors.
47	Pipe, tubing, hose, and fittings.
48	Valves.
49	Maintenance and repair shop equipment.
51	Handtools.
52	Measuring tools.
53	Hardware and abrasives.
66	Instruments and laboratory equipment
68	Chemicals and chemical products.
69	Training aids and devices.
75	Office supplies and devices.
79	Cleaning equipment and supplies.
80	Brushes, paints, sealers, and adhesives.
84	Clothing and individual equipment.
91	Fuels, lubricants, oils, and waxes.
95	Metal bars, sheets, and shapes.

(information) which make an item of supply different from every other item of supply. The amount and type of identification data would depend on the item and its intended use. Although the NIIN is part of the national stock number, it is used independently to identify an item. Most federal supply catalogs are arranged in NIIN order as will be illustrated in the section on material catalogs discussed later.

Special Material Identification Code (SMIC)

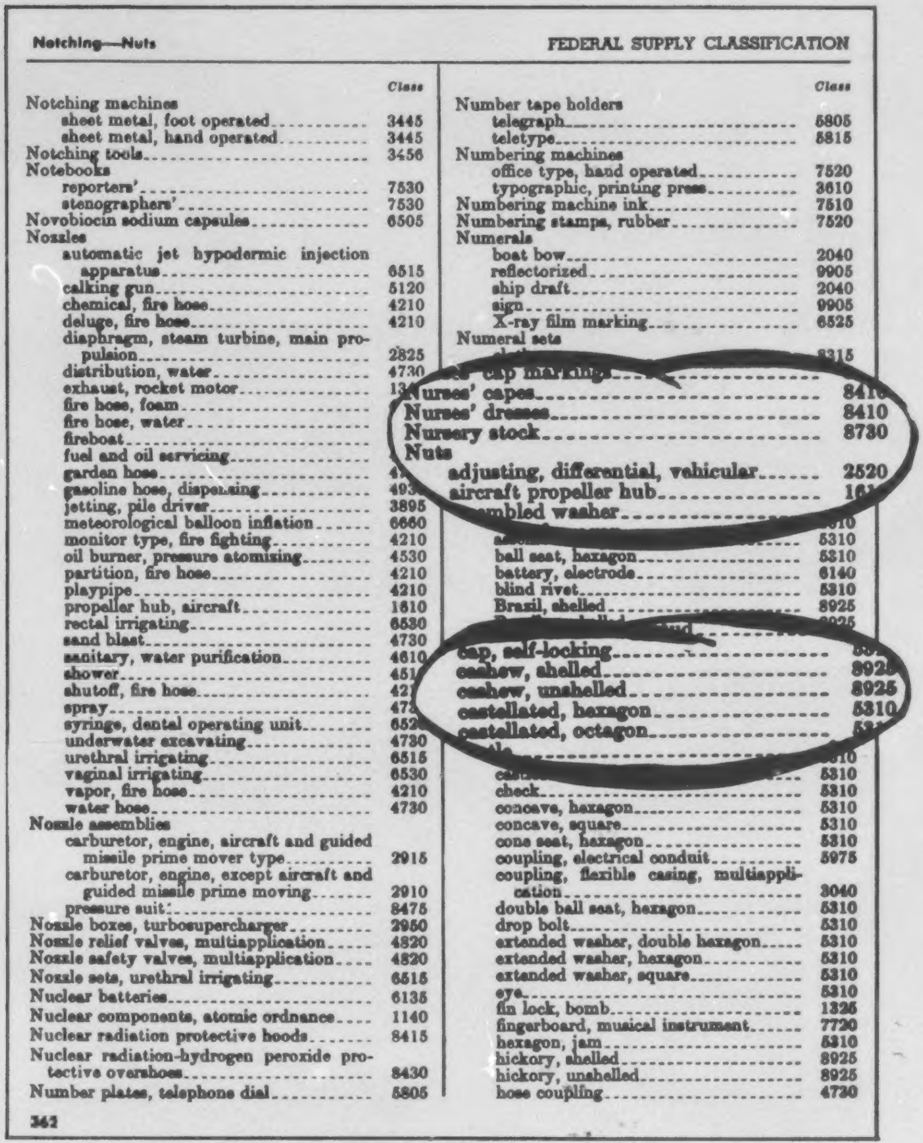
The special material identification code is a two-digit code suffixing the national stock number. It is used to identify items to aircraft models, engine models, certain commodities, and special projects or programs. The SMIC replaced the technical supply management code (TSMC) and the weapon supply management code (WSMC). Like many areas of supply where changes are made, a certain time element will be involved before all material catalogs are updated to reflect the SMIC.

The SMIC may be assigned by the inventory manager to an NSN when the NSN item requires source or quality control, design or figuration control, stocking issue and procurement control, and/or special testing, storage, handling, or inspection.

In the two-digit code the second digit has the greatest importance and gives the general usage of that particular item. The following is a listing of some of the more common second-position letters with their applications:

A – Attack aircraft
C – Cargo/transport aircraft
F – Fighter aircraft
H – Helicopters
P – Patrol aircraft
S – Antisubmarine aircraft
T – Trainer aircraft
U – Utility aircraft
X – Common/general items

The first-position letter has no meaning by itself. It merely subdivides the individual second-position letters. For example, the second-position letter "A" signifies an attack aircraft. The first-position letter breaks down the general type of attack aircraft into specific models. Examples of this breakdown are DA for A-4 attack aircraft, FA for A-6 attack aircraft, and GA for the A-7 attack aircraft. The first-position letter does not mean the same thing when used with a different second letter. For example, the letter "B" when used with the second letter "P" signifies a P-3 patrol aircraft. A cross-reference listing of aircraft, engine, special systems, and general/common SMIC assignments is provided in the Aviation Supply Office publication, Foreword for List of Repairable Assemblies and List of Supporting Spare Parts of Navy Aviation Materials.



Notching—Nuts

FEDERAL SUPPLY CLASSIFICATION

	Class
Notching machines	
sheet metal, foot operated	3445
sheet metal, hand operated	3445
Notching tools	3456
Notebooks	
reporters'	7530
stenographers'	7530
Novobiocin sodium capsules	6505
Nozzles	
automatic jet hypodermic injection apparatus	6515
calking gun	5120
chemical, fire hose	4210
deluge, fire hose	4210
diaphragm, steam turbine, main propulsion	2825
distribution, water	4730
exhaust, rocket motor	13
fire hose, foam	[illegible]
fire hose, water	[illegible]
fireboat	[illegible]
fuel and oil servicing	[illegible]
garden hose	47
gasoline hose, dispensing	493
jetting, pile driver	3895
meteorological balloon inflation	6660
monitor type, fire fighting	4210
oil burner, pressure atomizing	4530
partition, fire hose	4210
playpipe	4210
propeller hub, aircraft	1610
rectal irrigating	6530
sand blast	4730
sanitary, water purification	4610
shower	451
shutoff, fire hose	421
spray	473
syringe, dental operating unit	652
underwater excavating	4730
urethral irrigating	6515
vaginal irrigating	6530
vapor, fire hose	4210
water hose	4730
Nozzle assemblies	
carburetor, engine, aircraft and guided missile prime mover type	2915
carburetor, engine, except aircraft and guided missile prime moving	2910
pressure suit	8475
Nozzle boxes, turbosupercharger	2950
Nozzle relief valves, multiapplication	4820
Nozzle safety valves, multiapplication	4820
Nozzle sets, urethral irrigating	6515
Nuclear batteries	6135
Nuclear components, atomic ordnance	1140
Nuclear radiation protective hoods	8415
Nuclear radiation-hydrogen peroxide protective overshoes	8430
Number plates, telephone dial	5805

	Class
Number tape holders	
telegraph	5805
teletype	5815
Numbering machines	
office type, hand operated	7520
typographic, printing press	3610
Numbering machine ink	7510
Numbering stamps, rubber	7520
Numerals	
boat bow	2040
reflectorized	9905
ship draft	2040
sign	9905
X-ray film marking	6525
Numeral sets	
[illegible]	8315
es' cap markings	[illegible]
Nurses' capes	841
Nurses' dresses	8410
Nursery stock	8730
Nuts	
adjusting, differential, vehicular	2520
aircraft propeller hub	161
mbled washer	[illegible]
[illegible]	10
[illegible]	5310
ball seat, hexagon	5310
battery, electrode	6140
blind rivet	5310
Brazil, shelled	8925
[illegible]	[illegible]
[illegible]	[illegible]
cap, self-locking	[illegible]
cashew, shelled	892
cashew, unshelled	8925
castellated, hexagon	5310
castellated, octagon	[illegible]
[illegible]	10
[illegible]	5310
check	5310
concave, hexagon	5310
concave, square	5310
cone seat, hexagon	5310
coupling, electrical conduit	5975
coupling, flexible casing, multiapplication	3040
double ball seat, hexagon	5310
drop bolt	5310
extended washer, double hexagon	5310
extended washer, hexagon	5310
extended washer, square	5310
eye	5310
fin lock, bomb	1325
fingerboard, musical instrument	7720
hexagon, jam	5310
hickory, shelled	8925
hickory, unshelled	8925
hose coupling	4730

342

216.228

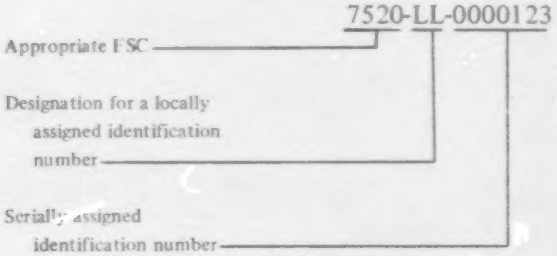
Figure 3-1.—Cataloging handbook H2-3—description to federal supply classification (FSC).

Local Item Control Number

Certain material categories are exempted from the federal cataloging system. Those materials exempted include:

1. Items procured on a one-time basis for immediate use in research and development, experimentation, construction, or maintenance. These items are not subject to centralized item inventory management, reporting, or stock control.
2. Items procured locally and intended solely for local use or consumption, and not subject to centralized management, reporting, or stock control.
3. Items obtained through overseas procurement and intended solely for overseas use.
4. Items procured with nonappropriated funds.
5. Items source coded in a series other than the P series in applicable NavAir publications.

Local item control numbers (formerly called local stock numbers) may be assigned to shipboard stocked consumable items which are not identified by an NSN, a NATO stock number, or another type of NICN. A local item control number will consist of 13 characters. The first four will be numerics that correspond to the FSC of similar NSN items; the fifth and sixth will be "LL" (signifying "locally assigned"); and the remaining seven will be numerics. For example:


7520-LL-0000123
Appropriate FSC
Designation for a locally assigned identification number
Serially assigned identification number

Locally assigned item control numbers are authorized for local use only (i.e., for shipboard stock records, locator records, bin tags, issue documents, etc.). They are not authorized in requisitions inasmuch as such item identification numbers would be meaningless to the supply source. If replenishment of a locally numbered item is required, it must be requisitioned by DD Form 1348-6.

The stem number is serially assigned starting with 00-0001. Each additional local item control number is assigned the next higher number. Stocks carried under these numbers are also reported to the cognizant inventory manager by supply to prevent duplication of manufacture or purchase of items and to give the manager an opportunity to identify the item to an existing NSN.

STANDARDIZATION OF ITEM NOMENCLATURE

The assignment of names of stock items is as important as the assignment of National Stock Numbers. When items are inducted into the supply system, official government nomenclature must be assigned. Often this item name plus additional descriptive data will differ from names of items previously used. If difficulty is experienced in locating a familiar item in the catalog, it is quite possible that the name has been changed to conform to a more general usage. For instance, it will be found that a "swab" is a small stick with a tiny wad of cotton on one end, and is used by the Medical Department. In order to clean the decks it will be necessary to think of another name for "swab." "Mops" will be found listed, together with the correct National Stock Number. Other examples are as follows–"Ceilometer" becomes "Projector, Cloud Height"; "Zipper" has become "Fastener, Slide Interlocking," etc.

MATERIAL IDENTIFICATION AIDS

There may be times when a part or some technical material is needed and the stock number is unknown. At other times some material may be on hand and its identity is not positively known. A knowledge of the several methods by which material may be identified is very helpful in speeding the completion of a maintenance task. There are many ways in which material may be identified. Certain data may be available which does not identify an item but may lead to positive identification. An aircraft part has a part number. The part number may be looked up in the IPB and identified by nomenclature and often by the stock number. If the stock number is not furnished in the IPB, it may be found by referring to the Cross-Reference Section C0006 of the Navy Stock List of ASO.

Some equipments have attached nameplates which provide such information as the manufacturer's name, make or model number, serial number, size, voltage, phase, etc. Identification data taken from the nameplate of the old part can be very helpful in procuring a replacement.

When only the description of the item is known, the best source for identification is the descriptive sections of the various Navy Stock Lists.

Various publications used in identifying material are described in the following paragraphs.

NavSup Publication 2002

NavSup Publications 2002 contains a complete numerical listing of all available naval aeronautic publications distributed by the Naval Air Systems Command. This list is a handy reference to publications that should assist you in the identification of material.

Illustrated Parts Breakdown (IPB)

The IPB and allowance lists continue to be the most important source for obtaining information necessary to order specific aircraft parts at the organizational level of maintenance. Properly used, they provide reference information necessary to identify a part number to the specific model aircraft, and in some cases provide interchangeability data that can be utilized when the prime item requested is not in stock. Parts interchangeability will be discussed in greater detail later in this chapter.

An Illustrated Parts Breakdown, also known as Illustrated Maintenance Parts List or Illustrated Parts Catalog, is prepared by the manufacturer for each model aircraft, engine, accessory, electronic equipment, or other aeronautical equipment considered advisable by NavAirSysCom and is printed and issued by the authority of NavAirSysCom. The IPB is designed to enable supply and maintenance personnel to identify and order replacements parts for the aircraft or equipment. All procurable assemblies and detail parts are illustrated and listed in such a manner as to make possible quick identification of assemblies and their component parts. The items are arranged continuously in assembly breakdown order with the illustrations placed as near as possible to their appropriate listing.

Although slight variations in format exist among the various IPBs, each usually includes the following major sections.

The TABLE OF CONTENTS shows the breakdown of the publication into sections. It also furnishes an alphabetical listing of the various assemblies and lists the page or figures where they are illustrated.

The INTRODUCTION includes general information and instructions for using the publication. It should be referred to prior to using an unfamiliar IPB.

The GROUP ASSEMBLY PARTS LIST is the main text of the publication. It consists of a series of illustrations and parts lists in which parts of the aircraft or equipment are shown in assembly-breakdown order. The illustrations and parts lists are keyed to each other by means of figure and index numbers.

Each assembly included in the parts list is followed immediately by its component parts properly indented to show their relationship to the assembly.

The group assembly parts list is subdivided into groups such as wing group, tail group, and fuselage. Some IPBs are multiple volume, and each group makes up a separate volume.

The NUMERICAL INDEX lists all parts numerically in part number order, and each part number is cross-referenced to the figure and index number where it is illustrated. This section also shows the total quantity of each part used in the aircraft or equipment, material source code, and national stock number when applicable.

The MASTER LOCATOR INDEX replaces the numerical index for some aircraft IPB volumes. The master locator index is used to locate the manual in which a part number appears when only the part number is known.

The part numbers are listed in alphanumerical order. The manual number appearing in the manual No. column refers to the last dash number of the NAVAIR manual number. For example, if the number shown in the manual No. column of the A-6 master locator index is 8, complete information on the part will be found in IPB volume, NAVAIR 01-85-ADA-4-8. The master locator index, unlike the numerical indexes, does not always provide source, maintenance, and recoverability information.

When using the IPB, consider if a failed part is one that was installed as a result of a technical directive, the part number may not appear in the IPB. The index manual for the IPB volumes will include a list of directives which have been incorporated into the IPBs. For information on parts where the directive has not been incorporated, the directive may provide the necessary information for ordering a replacement item.

Descriptive/Identification Lists and Illustrated Shipboard Shopping Guides

Descriptive type catalogs or Identification Lists (ILs) are available on all FSC group materials. These lists catalog material by what it is rather than by what it is used on. These catalogs are similar to the Sears-Roebuck/Montgomery-Ward type catalogs, which have a comprehensive alphabetical index, group like items together, and thoroughly describe the items (size, weight, composition, etc.).

The Illustrated Shipboard Shopping Guides (ISSG) are similar in many ways to the ILs. They are designed to assist fleet personnel in identifying those items of supply not normally related to a part number or reference number to an NSN. They also provide assistance in determining substitute items by virtue of illustrations, specifications, and narrative descriptions from which data can be compared.

The ISSG is a multivolume publication consisting of an introduction and master index plus a number of individual sections applicable to material in the specific federal supply classes or groups.

The master index provides an alphabetical sequence listing of all item names included in the ISSG, with reference to the individual sections (FSC group or class) wherein they appear. The index is similar to that shown in figure 3-1.

Figure 3-2 illustrates a page from the illustrated shipboard shopping guide, section 5310.

IDENTIFICATION SOURCE DATA

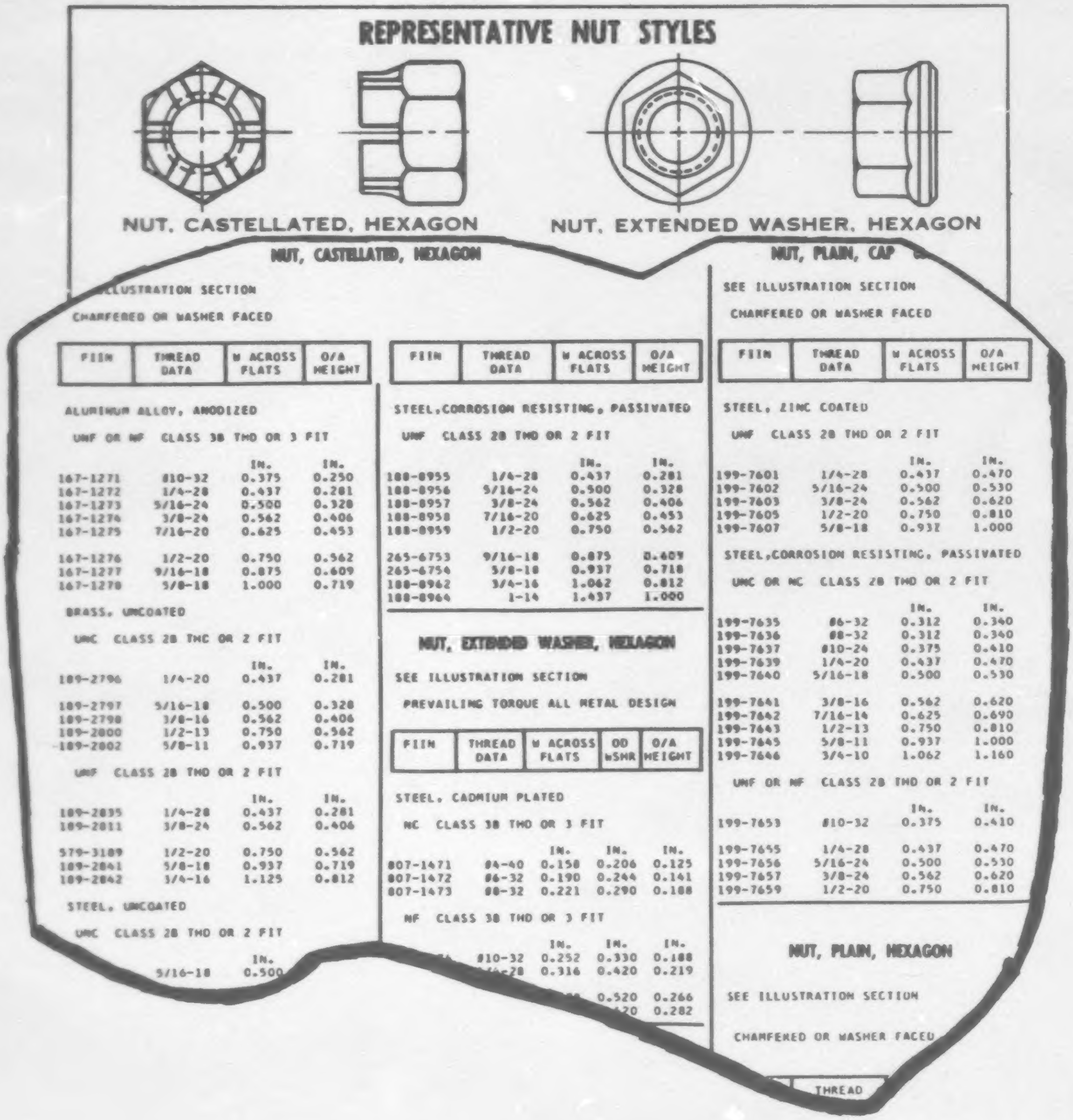
Positive identification of an item of supply has been accomplished when it is identified to its applicable national stock number. When the NSN is available, other required information, such as application, physical characteristics, etc., is easily obtained by referring to the appropriate supply catalog. The NSN is not normally marked on aircraft parts; however, most material has some type of data affixed to it that can be used for identification purposes. Certain data which does not identify an item but which aids in obtaining positive identification is discussed in the following paragraphs.

Manufacturer's Part Number

Normally, the manufacturers of parts stamp, etch, paint, or otherwise affix a part number on each item manufactured. The use of this manufacturer's part number and the knowledge of the part's application (that is, aircraft or equipment on which used) normally lead to the positive identification of the part's nomenclature and national stock number. The part number can be ascertained to be correct by reference to the appropriate Illustrated Parts Breakdown (IPB), and the national stock number may be obtained by reference to the appropriate Master Cross Reference Listing (MCRL).

Reference Number

The term reference number refers to a number assigned by the manufacturer or contractor. Part, serial, drawing, catalog, and specification numbers are all types of reference



REPRESENTATIVE NUT STYLES

NUT, CASTELLATED, HEXAGON
NUT, EXTENDED WASHER, HEXAGON

NUT, CASTELLATED, HEXAGON

LLUSTRATION SECTION

CHAMFERED OR WASHER FACED

FIIN	THREAD DATA	W ACROSS FLATS	O/A HEIGHT
ALUMINUM ALLOY, ANODIZED			
UNF OR NF CLASS 3B THD OR 3 FIT			
		IN.	IN.
167-1271	#10-32	0.375	0.250
167-1272	1/4-28	0.437	0.281
167-1273	5/16-24	0.500	0.328
167-1274	3/8-24	0.562	0.406
167-1275	7/16-20	0.625	0.453
167-1276	1/2-20	0.750	0.562
167-1277	9/16-18	0.875	0.609
167-1278	5/8-18	1.000	0.719
BRASS, UNCOATED			
UNC CLASS 2B THC OR 2 FIT			
		IN.	IN.
189-2796	1/4-20	0.437	0.281
189-2797	5/16-18	0.500	0.328
189-2798	3/8-16	0.562	0.406
189-2800	1/2-13	0.750	0.562
189-2802	5/8-11	0.937	0.719
UNF CLASS 2B THD OR 2 FIT			
		IN.	IN.
189-2835	1/4-28	0.437	0.281
189-2811	3/8-24	0.562	0.406
579-3189	1/2-20	0.750	0.562
189-2841	5/8-18	0.937	0.719
189-2842	3/4-16	1.125	0.812
STEEL, UNCOATED			
UNC CLASS 2B THD OR 2 FIT			
		IN.	
	5/16-18	0.500	

FIIN	THREAD DATA	W ACROSS FLATS	O/A HEIGHT
STEEL,CORROSION RESISTING, PASSIVATED			
UNF CLASS 2B THD OR 2 FIT			
		IN.	IN.
188-8955	1/4-28	0.437	0.281
188-8956	5/16-24	0.500	0.328
188-8957	3/8-24	0.562	0.406
188-8958	7/16-20	0.625	0.453
188-8959	1/2-20	0.750	0.562
265-6753	9/16-18	0.875	0.609
265-6754	5/8-18	0.937	0.718
188-8962	3/4-16	1.062	0.812
188-8964	1-14	1.437	1.000

NUT, EXTENDED WASHER, HEXAGON

SEE ILLUSTRATION SECTION

PREVAILING TORQUE ALL METAL DESIGN

FIIN	THREAD DATA	W ACROSS FLATS	OD WSHR	O/A HEIGHT
STEEL, CADMIUM PLATED				
NC CLASS 3B THD OR 3 FIT				
		IN.	IN.	IN.
807-1471	#4-40	0.158	0.206	0.125
807-1472	#6-32	0.190	0.244	0.141
807-1473	#8-32	0.221	0.290	0.188
NF CLASS 3B THD OR 3 FIT				
		IN.	IN.	IN.
	#10-32	0.252	0.330	0.188
	-28	0.316	0.420	0.219
			0.520	0.266
			20	0.282

NUT, PLAIN, CAP

SEE ILLUSTRATION SECTION

CHAMFERED OR WASHER FACED

FIIN	THREAD DATA	W ACROSS FLATS	O/A HEIGHT
STEEL, ZINC COATED			
UNF CLASS 2B THD OR 2 FIT			
		IN.	IN.
199-7601	1/4-28	0.437	0.470
199-7602	5/16-24	0.500	0.530
199-7603	3/8-24	0.562	0.620
199-7605	1/2-20	0.750	0.810
199-7607	5/8-18	0.937	1.000
STEEL,CORROSION RESISTING, PASSIVATED			
UNC OR NC CLASS 2B THD OR 2 FIT			
		IN.	IN.
199-7635	#6-32	0.312	0.340
199-7636	#8-32	0.312	0.340
199-7637	#10-24	0.375	0.410
199-7639	1/4-20	0.437	0.470
199-7640	5/16-18	0.500	0.530
199-7641	3/8-16	0.562	0.620
199-7642	7/16-14	0.625	0.690
199-7643	1/2-13	0.750	0.810
199-7645	5/8-11	0.937	1.000
199-7646	3/4-10	1.062	1.160
UNF OR NF CLASS 2B THD OR 2 FIT			
		IN.	IN.
199-7653	#10-32	0.375	0.410
199-7655	1/4-28	0.437	0.470
199-7656	5/16-24	0.500	0.530
199-7657	3/8-24	0.562	0.620
199-7659	1/2-20	0.750	0.810

NUT, PLAIN, HEXAGON

SEE ILLUSTRATION SECTION

CHAMFERED OR WASHER FACED

	THREAD

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Figure 3-2.–ISSG, section 5310.

numbers. However, for the purpose of this training, reference numbers relative to the identification of material are considered synonymous to parts numbers.

Drawing Number

A drawing number consists of letters, numbers, or a combination of both which are assigned to a particular drawing for identification purposes. The activity controlling the drawing (normally the manufacturer) assigns the number in conformance with their drawing number system. One drawing may apply to several items; thus, other distinguishing data may be necessary to identify the item on the drawing.

Drawing numbers may be used to identify the microfilm available in some technical libraries. Some large assemblies are illustrated in the appropriate Illustrated Parts Breakdown but are not broken down sufficiently to show identifying data for their component parts. By obtaining the drawing number of the larger item and cross-referencing it to the applicable microfilm, sufficient identifying information for the component part may be obtained.

Nameplates

Some aeronautical materials have nameplates attached which provide such information as the manufacturer's name or code, make or model number, serial number, size, voltage, phase, etc. Identification data taken from the nameplate of the old part can be very helpful in identifying and procuring a replacement. Nameplate data is particularly useful when requesting nonstandard material which is not subject to the federal cataloging system.

Markings and Measurements

Special coded markings, other than part numbers, and measurements often aid in the identification of some materials. For instance, compressed gas cylinders are color coded to identify the contents of the cylinders. Sheet metal is stamped with a significant identifying symbol which is repeated at intervals throughout the length of the sheet. This symbol includes the composition, temper, thickness, etc.

Flexible rubber hose is marked with a symbol which is repeated at intervals throughout the length of the hose. Bare wire is separated according to diameter. Tubing has two types of measurements—outside diameters, given in inches; and thickness of the wall, given in thousandths of an inch. Female fittings such as crosses, tees, and couplings are measured across the inside diameter of the threaded opening. The male fittings are measured across the outside diameter of the male threads.

Source, Maintenance, and Recoverability Codes (SM&R)

Uniform SM&R codes are used to identify the source of spares, repair parts and items of support equipment and the levels of maintenance authorized to maintain, repair, overhaul or condemn them. An objective of such coding is to control, by the application of sound maintenance and supply experience and judgment, the range of parts procured to support new equipments. Another objective of SM&R coding is to expedite the maintenance, repair and overhaul of aeronautical equipments by providing maintenance and supply personnel with the necessary information relative to the source of supply and, where applicable, the maintenance implications and recoverability status of items.

Uniform SM&R codes shall be used, to the maximum degree practicable, in all commodity areas where provisioning is practiced and shall be applicable to:

All new equipments being provisioned.

All equipments being reprovisioned.

Follow-on provisioning of equipments.

Equipments modified or added by
approved ECP actions.

See NAVAIRINST 4423.3 series and NAVSUPINST 4423.14 series for specific information concerning policies, procedures and responsibilities applicable to SM&R Codes.

The SM&R code format consists of a 6-digit number comprising three parts—a two-position source code, a three-position maintenance code, and a one-position recoverability code. The source code indicates the means of acquiring the item.

The third-position maintenance code indicates to maintenance and supply personnel the lowest level of maintenance authorized to remove and replace the item.

The fourth-position maintenance code indicates the lowest maintenance level authorized to accomplish repair, overhaul, or assembly of the item. Code Z in this position indicates that no repair is expected to be made at any level.

The fifth-position maintenance code indicates the lowest maintenance level authorized to condemn the items when repair or overhaul at this level or higher level is not economically or militarily justified.

The recoverability code indicated in the sixth position indicates special instructions on reclamation or disposition actions required on the item. Use of this position is temporarily being held in abeyance pending greater Department of Defense standardization of the codes. Material accountability/recoverability codes (MARC) are to be used separately pending approval of these codes for inclusion in the SM&R code format. An example of an SM&R code is PIHZH.

PARTS KITS

Supporting items and material for the maintenance, repair, and rework of selected repairable type items are procured, stocked, requisitioned, accounted for, and used on a kit basis as a single item. These parts kits should not be confused with Change Kits which are issued to perform a one-time modification of an item, nor with Interim Fleet Maintenance Support Kits which consist of a minimum range and quantity of parts and material to support the items until regular parts kits become available as a result of normal provisioning action.

A repair kit consists of a group of maintenance or overhaul parts that are bought, packaged, and stocklisted as a single item regardless of the supply classification of the items contained in the kit. Normally, these parts have either a very low unit cost or have a high replacement rate in overhaul or repair of the next higher assembly. Depending upon the complexity of the item to be repaired, there can be one or more kits needed for its repair. Repair kits are designed to serve three separate requirements as described in the following paragraphs.

C Kit (Cure-Dated Component Kit)

This kit provides cure-dated items such as diaphragms, packings, and O-rings. The C kit may also contain soft goods not subjected to age controls such as gaskets and seals, plus metallic items such as screws, nuts, and washers required to be removed when cure-dated or soft goods type material are replaced. When mixed categories of cure-dated parts are packaged in a single container, the controlling cure-date of the package is that of the oldest cure-dated part in the package. If cure-dated kits become over-aged due to the expiration of the storage limitations, the kit is administratively disposed of as excess material.

D Kit (Overhaul)

This kit contains hard good repair parts required at the time of overhaul. This kit does not contain cure-dated parts nor any metallic item which is placed in the C kits; thus, both are required at the time overhaul maintenance is being performed.

F Kit (Fleet)

This kit provides those items that are required to be replaced at intermediate and organizational maintenance levels. Replacement of F kit items normally does not require special tools or equipment. This kit does not contain cure-dated parts.

Part numbers for repair kits are listed in the applicable Illustrated Parts Breakdown and, in some cases, the Maintenance Instructions Manual.

The C, D, and F kits are assigned source codes of "PC", "PD", and "PF" respectively. However, space limitations in some catalogs restrict the code designation of kits to a one-position character; therefore, it may appear as C, D, or F as appropriate. Component parts of C, D, and F kits are source coded "KC", "KD", or "KF" respectively. Component parts source coded "KB" are components of both D and F kits.

AIMD personnel involved in overhaul or repair of components should determine if parts kits are available to expedite repair or overhaul. Ordering individual items when they are available in a kit creates unnecessary paper work that is time consuming and costly.

AERONAUTICAL ALLOWANCE LISTS

This title is inclusive of publications identified as Allowance Lists (except advanced base lists), Initial Outfitting Lists, and Table of Basic Allowances.

PURPOSE AND ORIGIN OF ALLOWANCE LISTS

Naval Air Systems Command Allowance Lists, Initial Outfitting Lists, and Tables of Basic Allowances are prepared by the NavAirSysCom or the Aviation Supply Office. In nearly all instances ASO has the responsibility for preparation, but in all cases these lists are published by the direction of and approved by the NavAirSysCom. These lists contain the following:

1. The equipment and material (both consumable and nonconsumable) necessary to outfit and maintain units of the aeronautical organization in a condition of material readiness.
2. Substantially all items used with sufficient frequency to justify their issuance to all activities maintaining aircraft or equipment for which the lists are designed.
3. Information concerning stock number, nomenclature, interchangeability, and supersedures.
4. A set of detailed instructions for the application and utilization of the publication.
5. A table of logistic data showing the total weight and cube of all material contained in the list.

In the final analysis, the equipment and spare parts listed in these publications are made available to aircraft operating and maintenance activities in accordance with assigned operational maintenance and logistics responsibilities through appropriate application of allowance lists and outfitting actions. The Aviation Supply Office has the responsibility for continually reviewing and updating allowance lists.

The Individual Material Readiness Lists, described later in this chapter, supersede several of the old allowance lists. For example, several of the allowance list sections QG, QO, QR, and QT series have been eliminated by the establishment of validated IMRLs.

Initial Outfitting Lists

Initial Outfitting Lists are publications which indicate the range and quantities of maintenance spare parts considered necessary to support various aeronautical end items. These lists contain repair parts, such as airframe parts, electronic parts, engine parts, and general aeronautical equipment. The material covered by Initial Outfitting Lists is normally retained in supply department stocks until required for issue. This allowance of material is provided to ships or activities and is firm only at the time of initial outfitting. Increases and decreases in both range and quantities of material are based upon usage data of each activity concerned. Each series list is designed to support an aircraft, electronic equipment, or some other aeronautical article.

Allowance Lists

These are publications which indicate the range and quantities of equipment and material considered necessary for maintenance support of assigned and/or supported aircraft. Generally, these items are in-use items required for daily or continual use, such as aircraft jacks, air compressors, and avionics test equipment.

Tables of Basic Allowance

Publications listing equipment and material required by activities for performance of assigned mission are known as Tables of Basic Allowance. They contain both shop equipment and common supporting spare parts. They cover allowances of tools and equipment required for use by such activities as Fleet Marine Force squadrons and target pilotless aircraft activities.

A complete listing of Aeronautical Allowance Lists, Initial Outfitting Lists, and Tables of Basic Allowance, with NAVAIRSYSCOM publication numbers and their effective dates, is contained in NAVSUP Publication 2002.

IDENTIFICATION AND TYPES OF ALLOWANCE LISTS

Initial Outfitting Lists and Allowance Lists are identified by the publication number NAVAIR 00-35Q series, while Tables of Basic Allowance are identified by the publication number NAVAIR 00-35T series. One example of a complete publication number for each of the two types of lists is included in the section breakdown which follows.

Section A, Standard Aeronautical Material and Naval Stock Account Material

Section A covers general material such as nuts, bolts, tubing, hose, paint, and other items common to the operation of all aircraft models. Both equipage and consumable supplies are shown. Quantities of consumable supplies appearing in section A are firm for initial outfitting and may be used as a guide for replenishment until sufficient usage data are available for determining requirements.

Section B, Aircraft Maintenance Parts

Section B contains airframe, engine, and accessories maintenance parts peculiar to each type of aircraft. A separate section B is issued for each model of aircraft. Quantities of items included in this section are the amounts estimated to be required for a given period of time (normally 90 days). Quantities of items appearing in the section B are firm allowances for outfitting only, and are used as a guide for replenishment until such time that sufficient usage data are available for determining requirements. Publication number example–NA 00-35QB-187, Initial Outfitting List for P-3A.

The QB-187 is arranged in three parts. Part 1 is a listing, in NIIN number sequence, of items that are normally stocked by the supply department supporting the particular type of aircraft. Part 2 contains a listing of items, with appropriate quantities, that should be carried in the rotatable pool. Part 3 contains a listing of those items and their appropriate quantities carried by the squadron as "in-flight maintenance kit" items. In addition, there is a part number index and an NSN index.

The arrangement and content of section B IOLs will vary somewhat depending on the type of aircraft. For example, the Section B IOL for a fighter type aircraft would not have Part 3 listed above. Instructions for use of the allowance lists are included in the introductory pages following the table of contents.

Section G, General Support Equipment for All Types, Classes, and Models of Aircraft

Section G (Series) lists the quantities of handtools, handling and servicing equipment, and material which are made available for maintenance support of aircraft as may be assigned or supported.

Section H, Flight Operational Material

Section H is applicable to carrier air wings and all Navy and Marine squadrons operating aircraft or having aircraft assigned. It contains items and quantities of flight operational material considered necessary to maintain the concerned activities in a continual condition of operational readiness.

Section Z

Section Z includes mobile electric powerplant spare parts and equipment, and spare parts support for aircraft support equipment. Section Z also indicates the quantities of maintenance spare parts estimated (at the time of initial outfitting) to be required for aircraft support equipment for a period of 90 days.

Tables of Basic Allowance

An example of a publication number of the Tables of Basic Allowance is as follows: NA 00-35T-40, Allowance List, Air Launched Guided Missile Activities.

The foregoing section list breakdown includes only those sections of professional interest to the AM. The complete list includes allowance lists for arresting gear and catapults, photographic, aerological, etc.

DEVIATIONS FROM ALLOWANCE LIST REQUIREMENTS

It is the policy of the NAVAIRSYSCOM to make available to each Navy activity the authorized equipment and repair parts necessary to ensure operational readiness. Allowance list requirements are not mandatory, and deviations are approved as pointed out in the following paragraphs.

Type, Force, and major operating commanders, or their subordinate logistics commanders, may authorize deviations from allowance list requirements including one-time in-excess issue of equipment for a requirement not considered generally applicable to other activities of the same type, or for independent operations of detached activities.

Organizational and intermediate maintenance activities often have requirements for equipment which does not appear on existing allowance lists. In some cases the equipment is requested because it is considered superior to existing equipment, or it may be the result of an entirely new requirement; that is, for rework of a component or to perform repairs or services for which no previous capability existed.

In order to assure that each request for deviation is properly reviewed and evaluated for validity and possible application to other maintenance activities, the originating activity should submit an official request to the Naval Air Systems Command Headquarters, via the chain of command (including the cognizant NAVAIRSYSCOMREP). The following general procedures are followed in approval or rejection for a new piece of support equipment where no previous capability or need existed.

The request, together with complete justification, should be forwarded via the chain of command to the NAVAIRSYSCOMHQ. The request should not be made through supply system channels. The type commander normally identifies, on the forwarding endorsement, the intermediate maintenance activity which will perform the equipment evaluation if different from the requesting activity.

The NAVAIRSYSCOMREP normally investigates the request and indicates on the forwarding endorsement the availability of the requested equipment from existing resources. Upon review and approval, the NAVAIRSYSCOMHQ provides the activity concerned with the equipment. This equipment is considered a prototype and is for evaluation. No additional equipment is normally procured until the validity of the need can be determined. During the evaluation, the type commander and cognizant NAVAIRSYSCOMREP perform monitoring actions and provide additional assistance as required.

The completed documentation of the evaluation is forwarded via the chain of command to the NAVAIRSYSCOMHQ. In the forwarding endorsement, the type commander normally suggests a criteria for allocation of equipment to other activities. Upon review of the evaluation report, the NAVAIRSYSCOMHQ notifies all concerned of the action taken. In case of approval, this includes ASO so appropriate action may be taken to ensure updating allowance lists.

AIRCRAFT MAINTENANCE MATERIAL READINESS LIST (AMMRL) PROGRAM

This program has provided for the development of data and documentation needed to determine and establish firm support equipment requirements and inventory control of aircraft maintenance support equipment. The objective of this program is to document factual data and in-use asset information concerning the support equipment which can be used by management for the following purposes:

1. Determine and establish allowance requirements for support equipment at intermediate and organizational maintenance activities.
2. Redistribute in-use assets.
3. Provide a base for budgeting support equipment.
4. Measure material readiness in view of support equipment availability.

The proper determination, budgeting, acquisition, and distribution of support equipment is the ultimate responsibility of NAVAIRSYSCOM. However, the bulk of the day-to-day work concerning the maintenance of records for equipment in-use and the location of this equipment is placed with the NAVAIRSYSCOMREPS LANT/PAC/PENSACOLA. They represent NAVAIR within geographical areas of responsibility. NAVAIRSYSCOMREP Pensacola's responsibility encompasses all of the naval air training activities. Some of the NAVAIRSYSCOMREP'S responsibilities include:

1. Scheduling, preparing, and maintaining Individual Material Readiness Lists for all Navy aircraft maintenance activities.
2. Obtaining in-use inventories and maintaining inventory data.
3. Maintaining an Application Data for Material Readiness List (ADMRL) file.
4. Furnishing consolidated inventory reports to NAVAIR for activities within their area of responsibility.
5. Participating in ADMRL technical review conference and AMMRL review boards.

APPLICATION DATA MATERIAL READINESS LIST (ADMRL)

This is a master list used to specify the requirements for each item of aircraft maintenance support equipment against each level of maintenance and selected ranges of each aircraft, engine, propeller, and system for which each item is needed. For example, it contains allowances for all the support equipment required to support the P-3C aircraft on both the AIMD and squadron level, based on the number of aircraft (for the squadron) or the number of systems supported (for the AIMD). This data is developed primarily from Aeronautical Allowance Lists. ASO maintains the master updated ADMRL on tape and furnishes it to the NAVAIRSYSCOMREPS when required. ASO enters all technical changes such as changes in quantity, additions of new items, deletions, or changes of maintenance levels, as approved by NAVAIR.

From this master file (ADMRL), the Individual Material Readiness Lists (IMRLs) are prepared. For example, when a squadron gets a completely new type of aircraft, the NAVAIRSYSCOMREP can extract the allowances of support equipment required for organizational level maintenance for that type and number of aircraft and construct an IMRL which becomes the squadron's allowance for support equipment.

INDIVIDUAL MATERIAL READINESS LIST (IMRL)

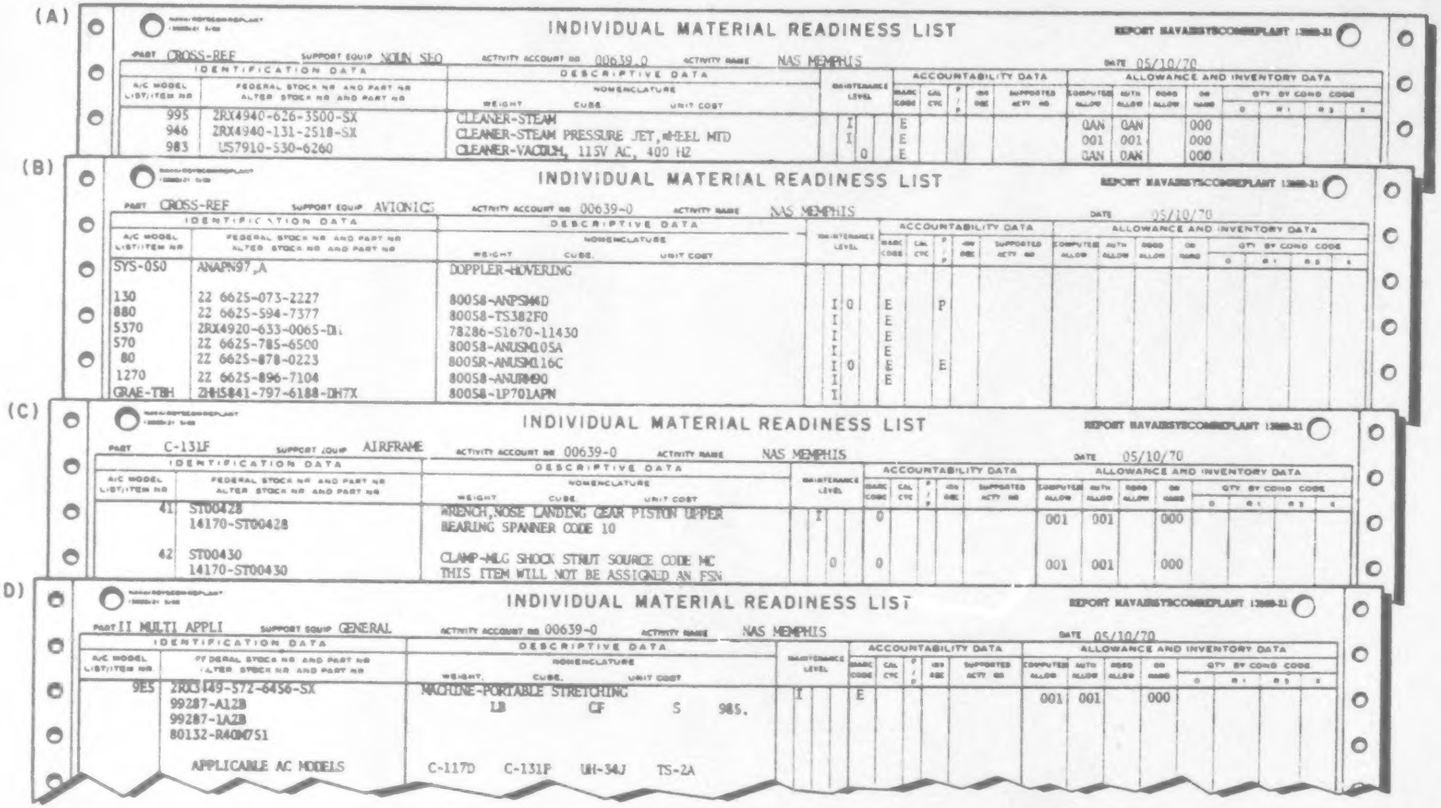
This is an allowance listing for GSE that is tailored to each organizational or intermediate maintenance activity based on the numbers and types of aircraft, aircraft engines, or aircraft systems supported.

The IMRL is printed in three basic sections which are discussed in the following paragraphs. Figure 3-3 illustrates the different sections of the IMRL.

Cross-Reference Section

This section is used to assist in identifying and locating material in the IMRL. It is broken down into three cross-reference parts to aid in this location and identification. The parts are as follows:

NIIN SEQUENCE CROSS-REFERENCE.–This part lists all prime items of equipment in NIIN sequence. The NIIN is cross-referenced to a sequence number (column 1) which shows the section of the IMRL in which that particular NIIN appears.



(A)

INDIVIDUAL MATERIAL READINESS LIST

REPORT NAVAIRSYSCOMREPLANT [illegible]

PART CROSS-REF SUPPORT EQUIP NOUN SEQ ACTIVITY ACCOUNT NR 00639-0 ACTIVITY NAME NAS MEMPHIS DATE 05/10/70

A/C MODEL LIST/ITEM NR	FEDERAL STOCK NR AND PART NR ALTER STOCK NR AND PART NR	NOMENCLATURE WEIGHT CUBE UNIT COST	MAINTENANCE LEVEL	MARK CODE	COMPUTED ALLOW	AUTH ALLOW	ON HAND
995	2RX4940-626-3500-SX	CLEANER-STEAM	I	E	0AN	0AN	000
946	2RX4940-131-2518-SX	CLEANER-STEAM PRESSURE JET,WHEEL MTD	I	E	001	001	000
983	US7910-530-6260	CLEANER-VACUUM, 115V AC, 400 HZ	O	E	0AN	0AN	000

(B)

INDIVIDUAL MATERIAL READINESS LIST

REPORT NAVAIRSYSCOMREPLANT [illegible]

PART CROSS-REF SUPPORT EQUIP AVIONICS ACTIVITY ACCOUNT NR 00639-0 ACTIVITY NAME NAS MEMPHIS DATE 05/10/70

A/C MODEL LIST/ITEM NR	FEDERAL STOCK NR AND PART NR ALTER STOCK NR AND PART NR	NOMENCLATURE WEIGHT CUBE UNIT COST	MAINTENANCE LEVEL	MARK CODE	P/P
SYS-050	ANAPN97,A	DOPPLER-HOVERING			
130	22 6625-073-2227	80058-ANPSM4D	I O	E	P
880	22 6625-594-7377	80058-TS382F0	I	E	
5370	2RX4920-633-0065-D1	78286-S1670-11430	I	E	
570	2Z 6625-785-6500	80058-ANUSM105A	I	E	
80	2Z 6625-878-0223	8005R-ANUSM116C	I O	E	E
1270	22 6625-896-7104	80058-ANURM90	I	E	
GRAE-TBH	2HS841-797-6188-DH7X	80058-LP701APN	I		

(C)

INDIVIDUAL MATERIAL READINESS LIST

REPORT NAVAIRSYSCOMREPLANT [illegible]

PART C-131F SUPPORT EQUIP AIRFRAME ACTIVITY ACCOUNT NR 00639-0 ACTIVITY NAME NAS MEMPHIS DATE 05/10/70

A/C MODEL LIST/ITEM NR	FEDERAL STOCK NR AND PART NR ALTER STOCK NR AND PART NR	NOMENCLATURE WEIGHT CUBE UNIT COST	MAINTENANCE LEVEL	MARK CODE	COMPUTED ALLOW	AUTH ALLOW	ON HAND
41	ST00428 14170-ST00428	WRENCH,NOSE LANDING GEAR PISTON UPPER BEARING SPANNER CODE 10	I	0	001	001	000
42	ST00430 14170-ST00430	CLAMP-MLG SHOCK STRUT SOURCE CODE MC THIS ITEM WILL NOT BE ASSIGNED AN FSN	O	0	001	001	000

(D)

INDIVIDUAL MATERIAL READINESS LIST

REPORT NAVAIRSYSCOMREPLANT [illegible]

PART II MULTI APPLI SUPPORT EQUIP GENERAL ACTIVITY ACCOUNT NR 00639-0 ACTIVITY NAME NAS MEMPHIS DATE 05/10/70

A/C MODEL LIST/ITEM NR	FEDERAL STOCK NR AND PART NR ALTER STOCK NR AND PART NR	NOMENCLATURE WEIGHT CUBE UNIT COST	MAINTENANCE LEVEL	MARK CODE	COMPUTED ALLOW	AUTH ALLOW	ON HAND
9ES	2RX3449-572-6456-SX 99287-A12B 99287-1A2B 80132-R40M751	MACHINE-PORTABLE STRETCHING LB CF S 985.	I	E	001	001	000
	APPLICABLE AC MODELS	C-117D C-131F UH-34J TS-2A					

211.73

Figure 3-3.—The IMRL. (A) The noun sequence cross-reference; (B) the avionics cross-reference; (C) Part I, the single application section; (D) Part II, the multiple application section.

NOUN SEQUENCE CROSS-REFERENCE.—In this part are listed all prime items of equipment in alphabetical sequence by noun nomenclature. Each item in this part is also cross-referenced to a sequence number column 1. An example of this part is shown in figure 3-3(A).

AVIONICS CROSS-REFERENCE.—In this part are listed all of the avionics systems applicable to that particular IMRL. The major avionics systems are listed in alphabetical order and all the test equipment allowed for a particular system is shown, indented three spaces directly underneath the applicable system. An example of this part is shown in figure 3-3(B).

Single Application Section

This section is composed of items that are applicable to only one specific aircraft model. An example of this section is shown in figure 3-3(C).

Multiple Application Section

This section contains those items that apply to more than one type of aircraft. Figure 3-3(D) illustrates this section.

Definition of Columns

The following subparagraphs explain the different headings and columnar format of the IMRL pages illustrated in figure 3-3.

IDENTIFICATION DATA.—This heading consists of two columns. In column (1) are listed the cross-reference sequence numbers. Shown in column (2) are the NSN, part number, and in the case of the single and multiple application sections, alternate items, which are indented three spaces immediately below the prime number.

DESCRIPTIVE DATA.—This heading consists only of column (3). A complete description of the IMRL item is shown; and in the case of the multiple application section, the multiple aircraft types to which the particular item applies are shown. Also provided is such information as weight, cube, and unit cost.

MAINTENANCE LEVEL.—This heading consists of columns (4) through (7). Column (4) is always left blank. Column (5) contains the letter "I" if the item applies to intermediate level maintenance. Column (6) contains the letter "O" if the item applies to organizational level maintenance. Column (7) contains the letter "T" if the item applies to transit support.

ACCOUNTABILITY DATA.—This heading includes columns (8) through (12). Column (8) contains the MARC code of the item. Column (9) contains a calibration cycle code, if applicable. Column (10) contains a pre-positioning code, if applicable. A pre-positioning code pertains to items applicable to organizational maintenance level items (code "O," column (6)) that must be checked out from the AIMD. The AIMD must account for and report these items. The following subparagraphs explain the three pre-positioning codes:

1. Code "P." This code indicates that the item is available on a subcustody basis from the supporting AIMD.
2. Code "E." This code indicates the item is available from the AIMD on an "as required" basis.
3. Code "L." This code identifies items which are issued to squadrons by the parent activity AIMD on subcustody but which may be retained by the squadron while they deploy.

Column (11) is left blank. In column (12), the activity's identification number is given.

ALLOWANCE AND INVENTORY DATA.—This heading includes columns (13) through (20). The following subparagraphs explain these columns:

1. Column (13). In this column is shown the allowance as extracted from the ADMRL.
2. Column (14), authorized allowance. This is the allowance as approved by the applicable NAVAIRSYSCOMREP and Air Type Commander.
3. Column (15), required allowance. This is the quantity deemed necessary by the applicable activity. It is not a firm allowance and if it does not agree with column (14), there should be a request for a change in allowance pending.

4. Column (16), on hand. In this column is shown the total on hand quantity for all condition codes.

5. Columns (17) through (20). These columns contain the quantity of items on hand by each condition code.

MAINTENANCE OF THE IMRL

The IMRL should be continually reviewed and updated by each activity to support current and anticipated changes in aircraft maintenance support equipment requirements. Because the IMRL is continually reviewed and updated and approved by the cognizant command, it is the firm mandatory material readiness list of the activity to which it applies. Maintenance of the IMRL usually becomes the responsibility of the senior AK attached to the activity to which it applies. Maintenance of the IMRL at the maintenance activity level consists of the following:

1. Establishing procedures for control and custody of accountable IMRL equipment.
2. Reporting all transactions involving the permanent transfer, receipt, or condition change (loss, etc.) of IMRL items via the appropriate transaction reporting form or card.
3. Conducting an annual physical inventory and submission of the annual inventory of IMRL equipment to the appropriate NAVAIRSYSCOMREP.
4. Ensuring that all shortages are ordered and followed up as necessary.
5. Consolidating, preparing, and submitting requests for IMRL changes to the appropriate NAVAIRSYSCOMREP.

Inventory and maintenance of an IMRL that meets the needs of the activity requires the cooperation of all maintenance supervisors. If the lack of appropriate equipment detracts from the activity's capability to perform certain maintenance tasks and the item is not on the activity's IMRL, addition of the item should be requested with adequate justification for the change in requirements. If an item on the IMRL is not required or the quantities are in excess of actual needs, again justify this fact and have the item deleted or a new allowance established so that the item may be redistributed as appropriate or dropped from the ADMRL master file. Annual physical inventories will require joint inventory by the AK maintaining the IMRL and the supervisors in charge of the IMRL equipment.

MARC (Material Accountability/ Recoverability Code)

MARCs were assigned to provisioned aeronautical items to identify the accountability, recoverability and repair policy determined for an item of equipment or material required for the maintenance, repair, or rework of an end article. The MARCs have been superseded by SM&R codes discussed earlier in this chapter. Until reassignment of SM&R codes are complete, however, MARCs may occasionally be found on previously coded items in the Navy inventory. Due to the changeover, MARCs will not be covered in depth in this text.

MANAGEMENT PROGRAMS FOR AVIATION REPAIRABLES

Within the naval aviation supply system, several programs have been established to enable ASO to maintain better visual contact of repairables and to ensure that unserviceable components are repaired in a timely manner. The programs discussed in the subsequent paragraphs of this section include HIVAC, which is applicable to both aviation and general supply system stock, and the NICRISP and CLAMP programs, which are applicable only to aviation repairables.

HIGH VALUE ASSET CONTROL (HIVAC)

By the issuance of SECNAV Instruction 4440.29 dated 18 June 1963, the Secretary of the Navy prescribed a program of high value item management for the Department of the Navy. The purpose of this program, High Value Asset Control (HIVAC), is to achieve inventory economies, without impairing combat readiness, through specialized management attention to the small percentage of items which represent the major segment of annual procurement expenditures.

It was estimated that the HIVAC program initially would encompass less than 1 percent of the items in the system inventory, but more than 40 percent of the annual dollar investment. ASO selected approximately 900 items to be included in the first increment of an expected ultimate selection of approximately 6,000 HIVAC items.

HIVAC items are selected according to the following criteria:

1. When, during periodic review or at the time of provisioning, system stocks are to be procured and in addition:

a. The forecast annual replenishable demand is equal to or greater than $40,000; or the total requirement for any future 12-month period, including outfittings and other program requirements, is predicted to be equal to or greater than $100,000; and

b. The procurement of new stocks is forecast in either the apportionment or budget year, if managed routinely; or expedited repair of recoverable material is necessary in lieu of procurement.

2. When it is planned to procure more than $100,000 worth of the item in either the budget or apportionment year to meet end use requirements, and no system stocks are to be procured.

Repairable HIVAC items are assigned material control code G and consumable HIVAC items are assigned material control code J and both have a unit cost of $1,000 or more.

NAVY INTEGRATED COMPREHENSIVE REPAIRABLE ITEM SCHEDULING PROGRAM (NICRISP)

NICRISP is a program established by ASO to increase the availability of RFI repairable components. NICRISP officials attempt to accomplish this task by weekly determining requirements for each repairable NSN and then directing the applicable depot level repair activities to repair enough unserviceable components to meet these requirements. NICRISP directives differ from other repair directives in the priority levels for repair. For example, when ASO directs a level 0 repair under NICRISP, the directive is to satisfy a priority 01 requisition or a NORS backorder. A level 1 NICRISP repair requirement is for all remaining backorders. A level 2 is for a system stock requirement for the next 30 days, and a level 3 repair requirement is for the next 60 days.

NICRISP affects the operating activity when a priority 01 or NORS order for an "R" cog repairable is placed and that item is not available in the aviation supply system in an RFI status. When ASO personnel receive the requisition, they screen their computerized records to locate an RFI asset. If none is available, they then screen their NICRISP schedule and their nonRFI assets to see if they can get one repaired to satisfy the requirement. ASO personnel then refer the requisition to the applicable DOP and have that station obligate the requisition against the NICRISP schedule. ASO then so informs the activity which originally ordered the item by sending the activity an advice code NF status document.

CLOSED LOOP AERONAUTICAL MANAGEMENT PROGRAM (CLAMP)

CLAMP is a program established by ASO to better manage critical aeronautical components. At the time of writing of this training manual, the program applied to components used on the A-7C, A-7E, F-14, and all models of the P-3 aircraft. The following subparagraphs contain brief discussions concerning the purpose of this program, criteria used for selecting CLAMP items, basic procedures followed by ASO field representatives in managing CLAMP items, and procedures for maintaining CLAMP stock.

Purpose

The purposes of CLAMP include the following.

1. To establish mandatory allowance quantities of CLAMP items for all operating units and to establish replenishment procedures on a one-for-one basis.

2. To provide a management information system for ensuring a one-for-one exchange of CLAMP items, for better controlling retrograde movement of them, and for serial number tracking.

3. To ensure there is a capacity at depot level maintenance activities to repair CLAMP items.

4. To maintain and store CLAMP items in segregated areas at DOPs, wholesale stock points, and operating sites (stations with AIMDs); and to ensure CLAMP items are stored in bonded warehouses at commercial overhaul sites.

5. To disseminate specific transportation procedures during the shipment of stock and retrograde CLAMP items.

6. To improve the control and scheduling of rework of these items at DOPs.

7. To collect usage data for bits and pieces used for depot level overhaul of CLAMP items.

8. To identify high failure components, faulty components, and unauthorized maintenance procedures.

9. To establish and maintain programs and reports to enforce discipline within CLAMP and evaluate the program.

10. To establish procedures for expediting bits and pieces for repair of CLAMP items at AIMDs.

Criteria

To be selected for intensive management under CLAMP, an item must be included in or be a component of one of the systems in the aircraft previously mentioned; it must be excluded from all other special management programs, and it should meet one or all of the following criteria:

1. Have a unit price of $10,000 or more; or
2. Have an annual repair cost of $100,000 or more; or
3. Become critical because of one or all of the following reasons:
   a. Excessive NORS/NFE days
   b. Excessive backorders
   c. Excessive AWP days
   d. Lack of system assets

AFR Procedures

The CLAMP program establishes a feature new to the aviation supply system, the ASO field representative (AFR). AFRs are assigned to selected operating units and wholesale stock point storage sites, at Naval Air Rework Facilities (NARFs, i.e., depot level maintenance activities), and to key transshipping points. They are responsible to the applicable ASO program manager for CLAMP items under that manager's control. Their responsibilities include the following:

1. Implementing and executing CLAMP procedures or assisting in these functions when necessary.

2. Maintaining transaction control records and making transaction reports for each action affecting CLAMP items. (See ASO Instruction 4440.92 (Series) for the various transaction reports.)

3. Submitting applicable CLAMP reports to ASO.

4. Auditing all CLAMP shipping documents related to retrograde shipments. This auditing function includes the following:

a. Ensure that the DD Form 1348-1 is properly filled out and includes the following data:

(1) Document identifier BC1 in CCs 1-3.

(2) AFR review in block C.

(3) The term "CLAMP" and applicable weapons system in block D.

(4) Serial number of the component in block V, if applicable.

(5) JCN in block W.

(6) Nomenclature in block X.

(7) Contract number, if applicable, in block Y.

b. Ensure packaging and preservation is in accordance with CLAMP specifications.

c. Ensure the shipment is executed as directed by the applicable weapons system manager procedures.

d. Ensure that each shipment includes the original and two copies of the DD Form 1348-1, a legible copy of the MAF, and that CLAMP labels are affixed to shipping containers to readily identify the components.

e. Make a written report concerning the results of this inspection.

5. They advise ASO program managers of areas requiring modification or improvement.

6. Attend conferences to review CLAMP status.

7. Maintain the warehouse or segregated storage area for all RFI CLAMP assets, all nonRFI CLAMP items, and all CLAMP items in an AWP status at that station.

8. Those AFRs assigned to DOPs maintain the following records concerning CLAMP:

a. Serial number record. The purpose of this record is to accumulate sufficient information to determine faulty maintenance practices at operating sites, recurring failures, and rework turn-around time. This record contains the following information:

(1) Date the component was received for rework.

(2) Activity the item was received from.

(3) Document number of the nonRFI receipt.

(4) Date of acceptance as RFI.

(5) Reasons for failure.

b. Shipment record. The purpose of this record is to record the shipment of all RFI units from depot level activities. The following documents are maintained in chronological order for each shipment of an RFI CLAMP item:

(1) Applicable DD Form 1348-1 shipping document.

(2) Messages from the DOP to operating sites providing shipment information.

(3) Messages from operating sites to DOPs reporting receipt of an RFI CLAMP item.

c. Receipt record. The purpose of this record is to record the receipt of all nonRFI units. It contains the following documents files in chronological order:

(1) Copies of the DD Form 1348-1 shipping documents.

(2) Copies of messages from operating sites providing shipping information.

(3) Copies of messages to operating sites reporting receipt of nonRFI units.

d. ASO master log. Each DOP AFR maintains an "ASO master log—retrograde/replacement pipeline" containing data for each NSN of nonRFI retrograde received and each RFI replacement item shipped.

9. Each operating site AFR maintains a "Stock Balance/Transaction Summary" record for each CLAMP item applicable to his activity. This record contains the document number, serial number, message (msg) date time group (DTG) number, and date shipped for each nonRFI shipment; the document number, serial number, msg DTG, and date received for each RFI unit received; and the balance on hand for both nonRFI and RFI units.

SUPPLY ACTIVITY

The mission of the supply activity is to support the operational and maintenance efforts of the activity/ship. Stocks of aviation-oriented material carried are tailored and replenished to this end. Positioning, replenishment, and control of stocks of material in maintenance areas are carried out as a result of joint decisions by the Supply and Maintenance Officers concerned. They determine the range, depth, and related procedures. The Navy Maintenance and Material Management System requires that the cost of material used in maintenance be determined and accumulated in such manner and detail that weapons system costing can be measured. Usage is finely defined as to stock number, within component, within system, within equipment/weapon/aircraft, in a particular squadron, located in a specific operational area, at a definite point in time. These data are used as an inventory management tool to determine geographic and strategic distribution of stocks of material. In addition, the data will be invaluable in establishing the material portions of work standards in maintenance.

Rotatable Pool

The supply support center maintains rotatable pool material which consists of repairable ready-for-issue items reserved primarily to satisfy the requirements of organizational level maintenance. Items maintained in the pool are capable of being repaired by the local intermediate maintenance activity, have application relationship to weapon systems supported by local intermediate maintenance activities, and have an average organizational maintenance level removal rate of at least one per month. Defective components are turned in to intermediate level maintenance for repair. The defective components repaired to an RFI condition are then returned to the rotatable pool to replace the components previously issued.

Generally, items included in a rotatable pool are repairable items of supply which are under the issue control of the local supply officer. However, instances may occur when it is desirable to position some items or assemblies (such as a pre-soaked carburetor, built-up wheel assembly, built-up prop, etc.) in the pool for use by organizational and intermediate maintenance activities. Prepositioning of items of this nature is acceptable as long as they aid in decreasing NOR time.

The local supply officer and aircraft maintenance officers concerned determine the range and quantity of each item required in the rotatable pool. Two elements used in this determination are the local repair cycle time and the local removal rate. The local repair cycle time is the average total elapsed time between removal of a component and the complete local repair of the item into an RFI condition. The local removal rate is the average number of defective components removed over a 3-month period, for which replacement RFI components were required.

After the components and the quantity of each that will be included in the pool have been determined, the supply officer publishes an official list of pool items. This listing provides a ready reference for the components carried in the pool. RFI rotatable pool items are withdrawn from the pool by the local supply officer only under the following conditions:

1. When actual usage indicates the item/quantity can no longer be justified as a reservation, and the aircraft maintenance officer concurs.
2. When requested by the aircraft maintenance officer.
3. Only as a last resort to satisfy nonlocal system requirements.

In order for the rotatable pool to fully serve its intended purpose there must be complete cooperation between maintenance and supply organizations. Organizational maintenance activities must expedite return of defective components to supply so that these components can be delivered to the intermediate activity for repair. The intermediate activity must complete repairs in an expeditious manner so that the repaired components can be returned to supply to be placed in the rotatable pool. Then, the supply organization is able to offer maximum support in the form of RFI components to ensure maximum aircraft readiness.

Preexpended Bins

Many items of low dollar value are repetitively used in the aircraft maintenance program. Such items should be available to maintenance personnel with a minimum of effort. The accepted practice is to stock these repetitively used items in the immediate maintenance area (frequently in the primary using shops) in a preexpended bin. A preexpended bin is one which contains only low cost, high usage items which have already been charged to final expenditure. Establishment, maintenance, and replenishment of preexpended bins are the responsibilities of the supply support center. Preexpended material is generally defined as commonly used consumables and repair parts with a unit cost of $25 or less and a quantitative limitation of one month's expected usage.

The purpose of the preexpended bin is to facilitate the issue and accounting procedure for recurring issues of NSA and APA items of small money value. The use of preexpended material system eliminates the time required to fill out and secure authorization on a requisition, the waiting time required to process the requisition through the supply department, the posting of the individual issues to stock records, and reduces the number of transactions processed through the supply department. The preexpended bins are located where they are readily accessible to shop personnel and, when feasible, are located where they can be observed by supply personnel attached to the retail issue organization. This permits prompt recognition of any abuses to the preexpended system.

Specific items to be carried in preexpended bins are determined jointly by the supply officer and the head of the department having cognizance over the shop in which such bins are located. Such items as nuts, bolts, screws, connectors, fuses, clamps, etc. are prime examples of items included in preexpended bins.

Eligible items having a unit cost in excess of $25 may be preexpended with the approval of the commanding officer provided the total preexpended inventory at any one outlet does not exceed an estimated 30-day supply. Items contained in critical or short supply lists published by cognizant inventory managers or other competent authority may not be preexpended. Attractive items or items considered subject to pilferage also may be preexpended; however, these items should be retained in an area under the control of the SSC.

The SSC will provide some aid so that maintenance personnel can readily determine what parts are available in pre-x. This can be accomplished by publishing a listing of those items available, by displaying them on a prominently located display board or in a display case, or any other suitable means.

Maintenance personnel should not abuse the convenience of the preexpended bins by hoarding quantities of items in excess of their needs or by removing desired items from the display board vice obtaining it from pre-x bins.

MATERIAL CONTROL WORK CENTER

The material control work center in a maintenance activity performs a staff function and, as such, provides support and services to the production divisions. It exists for the primary purpose of ensuring that maintenance requirements for parts and materials are made known to the supply organization in a timely manner in order to prevent work stoppages and grounding aircraft. Material control ensures that parts and materials made available to maintenance are systematically utilized and not allowed to accumulate or to become depleted. It serves as the single point of contact within the maintenance organization for the conduct of business with the supply organization.

The material control work center provides material support to their cognizant organization by accomplishing the following general functions:

1. Pass all requirements for material required for direct support of weapon system maintenance to the SSC. A material control register is maintained for these items.
2. Prepare documents for materials required for indirect support of weapon system maintenance. Examples of materials for which documents are to be prepared are aviation fuels and lube oils, rags, and flight jackets. A separate requisition record log is maintained for these items.
3. Maintain liaison with the supporting SSC on maintenance material matters to ensure that material needs of the organization are satisfied.
4. Establish delivery points for all material and ensure that material received is expeditiously routed to the applicable work center.
5. Furnish technical advice and information to the supply activity on the identity and quantity of supplies, spare parts, and materials required for maintenance actions.
6. Establish procedures to ensure the periodic inventory of tools and the adequate accountability of material and equipment on custody to the cognizant organization.
7. Initiate surveys in the event of loss, damage, or destruction of accountable material.
8. Keep the maintenance control work center advised of the overall supply situation as it affects the activity.
9. Perform cost and allotment record accounting, charting, and budgeting of cost applicable to the cognizant organization.
10. Monitor the operation of toolrooms and maintain an updated IMRL.
11. Maintain inventory control of authorized allowances of material.

The material control work center is responsible for the coordination of material ordering, receipt, and delivery. This is done in such a manner as to ensure that the correct material is ordered and that it reaches the work center within the specified time frame.

The foregoing functions of the material control work center apply to both organizational and intermediate level activities. Some of the functions which are applicable to one level only are listed in the following paragraphs.

ORGANIZATIONAL LEVEL

In addition to the general functions, the material control work center in organizational level activities is responsible for the following:

1. Verification of NORS (Not Operationally Ready Supply) requisitions and maintenance of current NORS status records.
2. Inventory of aircraft upon receipt and transfer and maintenance of inventory records.

When removed components are generated as a result of the maintenance effort, material control ensures that the SSC is notified to make a pickup. These components must be accompanied by record cards and logs, when applicable, plus the number two, three, and four copy of the Maintenance Action Form.

INTERMEDIATE LEVEL

An Administrative Screening Unit has been established in the material control work center of intermediate maintenance activities. This screening unit does the following:

1. Positively identifies material and determines if it is within the repair capability of the intermediate maintenance activity (AIMD).
2. Ensures that all required documentation is affixed to the component (that is, logs, records, MAF, etc.).
3. Notifies maintenance control of the receipt of defective components for scheduling into the AIMD.
4. Transfers the defective components to the appropriate work center when directed by maintenance control.

All components received in the AIMD material control receive screening to determine if the item is within the check, test, or repair capability of the AIMD. As a result of this screening, components requiring maintenance within the AIMD capability are reported to maintenance control as ready for induction. Items beyond AIMD capabilities are returned to the Supply Support Center with appropriate recommendations for disposition. When work on components in the AIMD has been completed, the components, together with required records, are returned to material control for appropriate routing back into the supply organization.

MATERIAL CONTROL REGISTER

The Material Control Register is used by intermediate and organizational level material control work centers to record all material requested from the Supply Support Center in direct support of weapon system maintenance. Space is provided to record essential information considered necessary to monitor operating target (OPTAR) funds. This information includes part number, priority, quantity, price, date and time ordered, and date and time received. Maintenance control uses the time ordered and time received to help determine Not Operationally Ready Supply (NORS) time used in fulfilling readiness reporting requirements.

MATERIAL REQUISITIONING

The Military Standard Requisitioning and Issue Procedure (MILSTRIP) and Uniform Material Movement Issue Priority System (UMMIPS) were developed by the Department of Defense to provide a common supply language and more effective supply system operations within the military establishment. This system standardizes forms, formats, codes, procedures, and the priority system.

MILSTRIP employs two forms for the requisitioning and issuing of material. The Single Line Item Requisition Document (Form DD 1348) is the basic request document submitted to the applicable supply echelon for material requirements. The issue document is the Single Line Item Release/Receipt Document (Form DD 1348-1). Form DD 1348-1 is also used to return RFI material to the supply system. As previously stated, these forms will be prepared by the Supply Response Section of supply for all material requested in direct support of

Table 3-5.—Issue priority designator conversion table

URGENCY OF NEED DESIGNATOR (UND)	FORCE/ACTIVITY DESIGNATOR (FAD)				
	I	II	III	IV	V
	PRIORITY DESIGNATOR (PD)				
DESIGNATOR A Emergency requirements for nonavailable material without which the force/activity concerned is unable to perform assigned missions or tasks.	01	02	03*		
				07	08
DESIGNATOR B Requirements for nonavailable material which impairs the capability of the force/activity concerned. Missions can be performed, but with decreased operational effectiveness and efficiency.	04	05	06**		
				09	10
DESIGNATOR C Requirements to replace administrative support equipment or systems not immediately essential to the mission or an aircraft or unit; routine stock replenishment; and routine scheduled maintenance/repair material.	11	12	13	14	15

NOTE: *.—A priority designator of 03 will be used for medical or disaster supplies or equipment required immediately for: prolonging life; relieving avoidable suffering; expediting recovery in case of injury, illness, or disease; or avoiding or reducing the impact of epidemics or similar potential mass illness or diseases when in professional opinion the probability is imminent. This priority designator will also be used for emergency supplies or equipment required immediately for controlling civil disturbance, disorder, or rioting.

NOTE: **.—A priority designator of 06 will be used by all activities when ordering a system identified HIVAC item unless a priority 01-05 is otherwise authorized. It will also be used for emergency supply of individual or organizational clothing required immediately to provide a minimum of essential clothing to active duty military personnel who are without the clothing required.

weapon system maintenance and by the material control work center for material requested in indirect support of weapon system maintenance.

Under the UMMIPS there is no decision to be made in assigning priorities. In addition to providing standardized criteria for assigning priorities, the system provides acceptable maximum processing times for use by supply activities in furnishing the material.

Two factors determine which of the fifteen authorized priorities should be assigned to each request for material—the force/activity designator (FAD) and the urgency of need designator (UND). A conversion table is provided by table 3-5.

The force/activity designators represent categories of activities in descending order of military importance, ranging from the combat forces under I to the miscellaneous activities under V. Every activity is assigned one of the five force/activity designations according to their military importance. These designations are as follows:

I–COMBAT–The highest order of military importance. This designator is not used in peacetime unless specifically designated by the Secretary of Defense upon the recommendation of the Joint Chiefs of Staff.

II–POSITIONED–U.S. Forces positioned and maintained in a state of readiness for immediate combat or direct combat support.

III–READY–U.S. Forces maintained in a state of readiness to deploy for combat.

IV–RESERVE AND SUPPORT–U.S. active and selected reserve forces planned for employment in support of approved joint war plans. This category includes training units and units in training for scheduled deployment.

V–OTHERS–All units not otherwise assigned.

Force/activity designators are assigned by the Secretary of the Navy, the Chief of Naval Operations, and Commanders in Chief of Fleets. Authority to make assignments may be delegated to Fleet Commanders with the exception of I–COMBAT. Each activity is advised by the appropriate military commander of the assigned designator which governs the procurement of material for that activity.

Urgency of Need Designators (UNDs) indicated by the capital letters A, B, and C down the left side of table 3-5 identify the existing situation caused by the particular lack of parts. Table 3-5 briefly describes the general criteria for assignment of the UND. Table 3-6 contains the detailed criteria for assignment of the appropriate UND. The urgency category is selected by the requesting activity.

If a squadron or unit has been assigned force/activity designator III and a work center supervisor determines that a part or some material is needed which if not received will impair the capability of the aircraft to perform its assigned mission, then the priority assigned must be number 6. The only other priorities available to force/activity designated III units or squadrons are 3 and 13.

The two allowable exceptions to the force/activity designator governed priority number system are indicated by the notes in Table 3-5.

MATERIAL TURN-IN

There are two main reasons for turning in material–the first and most common is the turning in of a damaged, wornout, or otherwise inoperative part in exchange for a like RFI item; and second, returning of material for credit, such as excess material or material received in error.

When it is determined that a needed part is an exchange item, the old part should be cleaned of grease and dirt, drained, flushed, or purged as necessary before turning it in. It is the responsibility of the maintenance personnel to attach aircraft equipment condition tags directly to the repairable item. An aircraft equipment condition label is applied to the exterior of the container. All turn-in material should be returned, if practicable, in the container in which the new item was received.

Activities placing items into shipping containers are responsible for the accuracy and completeness of information on the tag and the label, including the necessary obliteration of previous markings on the container which no longer apply. The primary reason for these tags and labels is to provide a means of identification and condition without disruption of packaging or preservation. These tags and labels indicate the required disposition to those processing the material through channels.

When a defective repairable item is turned in, the following forms are required–copies two, three, and four of the multicopy Maintenance Action Form and the Scheduled Removal Component Card (SRC) when applicable. The supply department uses copy two of the MAF for bookkeeping purposes. Copies three and four of the MAF accompany the item to the intermediate maintenance activity. When repair is completed by the AIMD, copy four of the MAF is attached to the RFI item and the item is returned to the supply system.

Table 3-6.–Urgency of need designators (UND) with definitions applicable to aviation units including AIMDs

UND (A)

1. Emergency requirements for primary weapons, equipment, and material for immediate use without which the aircraft concerned is unable to perform assigned operational missions (NORS). (See Note 1.)

2. Items required for immediate end use in direct support of equipment essential to the operation of aircraft (e.g., ground support, firefighting, etc.) without which the aviation unit is unable to perform its mission. (See Note 1.)

3. Items required to eliminate an existing work stoppage at an intermediate maintenance activity modifying or maintaining primary aircraft or aircraft equipment.

4. Items required to eliminate an existing work stoppage at an intermediate maintenance activity performing repair and maintenance on unserviceable high value/critical item repairables.

5. Items required to effect emergency replacement or repair of essential physical facilities of an intermediate maintenance activity, without which the activity cannot carry out its mission. (See Note 1.)

6. Not Fully Equipped (NFE) requirements, only when the items are needed to return mission essential subsystems and equipments to operational status.

UND (B)

1. Items required for immediate end use, the lack of which is impairing the operational capability of the aircraft or organizational unit concerned.

2. Items required for immediate end use to effect repairs to aircraft and aircraft support equipment, without which the operational capability of the aircraft is impaired or effectiveness in accomplishing assigned missions is reduced.

3. Items required for the replacement of mission essential items on allowance/load lists where the last item has been issued out of bin to end use or the quantity remaining is less than the minimum replacement unit.

4. Material required for immediate use to repair unserviceable repairable items identified as high value items or critical items by ASO/NAVAIR.

5. Items required to effect replacement or repair of physical plant facilities in an intermediate maintenance activity without which the effectiveness of the facility is impaired.

6. Items required for immediate installation to effect repair or replacement of auxiliary equipment without which the effectiveness of the assigned mission is impaired.

7. Required to preclude an ANTICIPATED work stoppage in performing maintenance on mission essential equipment. The work stoppage is anticipated within 12 days by CONUS activities and 17 days by overseas activities.

UND (C)

1. Items required to repair or replace administrative support equipment or systems not immediately essential to operational missions of aircraft or organizational units.

2. Items required for routine stock replenishment.

3. Items required for scheduled maintenance and repair, not immediately required.

NOTE 1: Requirements of this nature are of such a consequence as to require a report to higher authority of a degradation of the requisitioning unit's capability in accordance with established NORS procedures.

If material being turned in is no longer required and is RFI, a Single Line Item Release/Receipt Document (DD 1348-1) is submitted with the item. RFI means ready for issue in all respects–preservation still intact and item in original or reusable container with seals unbroken.

AERONAUTICAL MATERIAL SCREENING UNIT (AMSU)

Components that are turned in to the AIMD material control area are processed through the aeronautical material screening unit to determine whether the item is within the check/test/repair capability of the AIMD and whether such check/test/repair action is desirable.

When work on components processed and inducted into the AIMD has been completed, the component is returned to material control who, in turn, notifies the SSC that the component is ready for pickup and ultimate return to the pool or supply stock, as applicable.

Under normal circumstances, the determination of repair capability or noncapability must not exceed 24 hours for critical aeronautical material equipment list items and 3 work days for other items.

CHAPTER 4

CORROSION CONTROL

Corrosion in naval aircraft is a problem requiring the continued attention of all maintenance personnel. The environment in which naval aircraft operate promotes the development of corrosion and requires that specific and continuous measures be applied for its prevention and control.

The high stress loads imposed on modern aircraft and the use of newer lightweight materials in their construction make it even more important that the structural soundness of the weapon system be maintained throughout its service life. Without anticorrosion maintenance, the aircraft would soon deteriorate and become unsafe for flight.

In the past, lack of emphasis or a complete absence of proper corrosion preventive maintenance resulted in aircraft requiring extended rework at overhaul activities. This situation had serious effects on the Navy's goal of maximum utilization of all available weapon systems and has resulted in the strict requirement for an active corrosion control program for each activity involved in maintaining naval aircraft.

CORROSION CONTROL PROGRAM

The ability to control corrosion is dependent on an active and continuous program. The Senior Aviation Structural Mechanic will frequently be responsible for supervision of corrosion maintenance on a program, divisional, or shop level. In most cases the activity will have a fully implemented corrosion control program in existence, but without proper direction and motivation provided by the immediate supervisor, the program can easily become stagnant. Information on the types and nature of corrosion and general maintenance practices is provided in Chapter 11, Rate Training Manual, *AMS 3 & 2*, NAVEDTRA 10308-C. In this chapter, this coverage is expanded and given direction.

ELEMENTS OF AN ACTIVE PROGRAM

The corrosion program that strives to be continuously dynamic must have coordination and motivation. Maintenance/production control is charged with the responsibility of controlling and directing all maintenance efforts within an activity; however, this responsibility is met through the use of subordinate supervisors. In pursuing a complete program of corrosion control, numerous elements must be considered; and while they are generally the concern of maintenance control, it is the unit's corrosion program supervisor who provides the necessary coordination, direction and motivation. The supervisor should be knowledgeable of the information provided in the following publications:

1. *Aircraft Cleaning and Corrosion Control for Organizational and Intermediate Maintenance Levels,* NAVAIR 01-1A-509.
2. *Preservation of Naval Aircraft*, NAVAIR 15-01-500.
3. Appropriate volume of the applicable Maintenance Instructions Manual with specific corrosion control instructions for the weapon system being supported.

While much has been done to improve the corrosion resistance of aircraft in the areas of improved materials, surface treatment, insulation, and protective finishes, corrosion continues to be a very real problem. A corrosion program designed to provide a reasonable solution must include the following elements:

1. Thorough cleaning, preservation, and lubrication at prescribed intervals.
2. Inspection for corrosion damage and protective finish integrity on a scheduled basis.
3. Prompt treatment after detection.
4. Accurate recordkeeping and reporting of material/design deficiency.
5. Adequately trained personnel in areas of detection, treatment, and prevention.
6. Adequate materials, equipment, and technical publications.
7. Proper emphasis on the concept of all-hands responsibility for corrosion control.

Training of personnel in proper methods is especially important. Occasionally, maintenance personnel not equipped to treat corroded areas cause more damage and actually aggravate the existing situation rather than control it. The unit's training syllabus should provide thorough training, and corrosion team members should receive the benefit of the special courses offered by the Naval Aviation Maintenance Training Groups and some of the Naval Air Rework Facilities. Team members should be assigned on a permanent basis with normal rotation to other billets within their rating to ensure that the repetition of corrosion control tasks does not lead to program stagnation.

EVALUATING THE EFFECTIVENESS OF A CORROSION PROGRAM

The effectiveness of the corrosion program is best reflected by the condition of the weapon system during periodic inspections and can be evaluated by proper recordkeeping and reporting of treatment required on each aircraft and its components. Fullest advantage must be taken of prescribed inspections to detect incipient corrosion or deterioration, to take immediate action to prevent further deterioration, and to correct existing discrepancies.

Documentation of Treatment

All manhours expended towards the corrosion control effort must be documented on the required maintenance data collection forms. Occasionally, activities tend to overuse the Support Action Form (SAF) for this purpose. While the SAF is used to account for washing, rinsing with water, touchup painting, and all other actions taken to PREVENT corrosion on aircraft and support equipment, the Maintenance Action Form (MAF) is used to document all actions requiring the preparation, treatment, and repair of corroded items, including the painting of areas which have been treated for corrosion. The use of the MAF to document corrosion treatment actions serves to identify the Work Unit Code (WUC) and provides a record of treatment to specific areas for future reference.

Reports

When it is considered necessary to monitor a corrosion program or investigate how much actual corrective corrosion treatment is being done by an activity, the maintenance data collection system information can be retrieved through the supplementary Corrosion Control/Treatment Report (MDR-S-4). This report lists all support action code 040 (corrosion control) and action taken code Z (corrosion treatement) transactions for the month. The report could reveal that one aircraft or component required more attention than others during specific periods. This may be due to where the aircraft has been in relation to other squadron aircraft (deployed, etc.) or may point out a need for a better corrosion program with respect to specific portions of the aircraft, as indicated by WUCs or whenever special operations or deployments are involved.

All instances of material or design deficiency with respect to corrosion should be reported on the Unsatisfactory Material/Condition Report Form, OPNAV 4790/47.

Some type commanders encourage the use of aircraft silhouette drawings similar to those illustrating the corrosion-prone areas of specific aircraft in the NAVAIR 01-1A-509 manual to indicate areas that have received extensive corrosion treatment. On transfer of the aircraft to Progressive Aircraft Rework (PAR) or another reporting custodian, this sheet serves to pinpoint areas that may require additional attention.

BUILT-IN ANTICORROSION PROTECTION

Aircraft design requirements emphasize the strength-to-weight ratio of the various metals used in aircraft construction and relegate corrosion resistance to secondary importance. Selection of corrosion-resistant materials would impose a weight penalty more prohibitive than the cost involved in a program of corrosion prevention by proper maintenance.

In view of the foregoing and the increasing cost of combating corrosion, aircraft manufacturers have been forced to develop and incorporate a variety of built-in anticorrosion features such as surface finishes, pretreatments, sealant and insulating materials, etc., which if properly maintained, should provide acceptable corrosion resistance throughout the service life of the aircraft.

METAL FINISHING

The main purpose of metal finishing is to provide corrosion resistance; however, surface finishes may also be applied to metal parts to increase wear resistance or to provide a suitable base for paint.

In most cases the original finishes cannot be restored in the field due to nonavailability of equipment or other limitations. However, an understanding of the various types of metal finishes is mandatory if they are to be properly maintained in the field and if the partial restoration techniques used in corrosion control are to be effective.

Surface Preparation

Surface preparation of steel parts usually includes a cleaning treatment to remove all traces of dirt, oil, grease, oxides, and moisture. This is necessary to provide an effective bond between the metal surface and the final finish. The cleaning process may be either mechanical or chemical, depending upon the composition of the part and the choice of final finish.

Steel parts are pickled to removed scale, rust, and other foreign matter, particularly before plating. The pickling solution is either hydrochloric (muriatic) or sulfuric acid. Costwise, sulfuric acid is preferable, but muriatic acid is more effective in removing certain types of scale.

The pickling solution is kept in a stoneware tank and is usually heated by means of a steam coil. Parts not to be electroplated after pickling are immersed in a lime bath to neutralize the acid from the pickling solution.

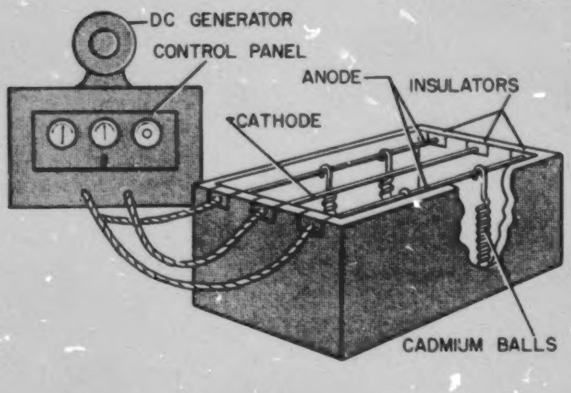
Aluminum and magnesium parts are also cleaned in preparation for a final finish. Blast (mechanical) cleaning is not applicable for thin aluminum sheets, particularly Alclad. Steel grits are not used on aluminum or corrosion-resistant metals. All cleaning processes used on magnesium and aluminum are, in general, milder than those used for steels.

Polishing, buffing, and coloring of metal surfaces play very important parts in the finishing of metal surfaces. Polishing and buffing operations are sometimes used when preparing a metal surface for electroplating, and all three operations may be used when the metal surface requires a high-luster finish.

Electroplating

Electroplating is the process of transferring metal from one object to another by chemical and electrical means. The metal deposited is called the plate, and the surface which receives the deposit is called the base.

All electroplating processes are basically similar. The equipment used consists of a tank or bath containing a liquid solution called an



214.8

Figure 4-1.—Electroplating equipment.

electrolyte, a control panel, and a source of direct current. (See Fig. 4-1.)

The item to be plated is made the negative pole or cathode; the plating material is introduced as the positive pole or anode. Both are immersed in the electrolyte and connected externally to the source of direct current. When the current is passed through the circuit, the anode is chemically eaten away and changed to charged metal particles in solution. This chemical change is called oxidation and results from loss of electrons by the metal going into solution. The charged metallic particles in solution pick up electrons from the negative pole and change to free metal on the surface of the base metal. This gain of electrons is called reduction. The process is continued until a plating of the required thickness is obtained. The electrolyte, anode, cathode, and current setting vary with the type plating material being used.

NOTE: Some plating operations do not use anodes of the metal that is being deposited but obtain the metal from the electrolyte alone. Chromium plating is an example of this type plating process. Insoluble lead anodes instead of chromium anodes, which are unsatisfactory, are employed to complete the electrical circuit; and the chromium from the plating comes from the chromic acid in the electrolyte.

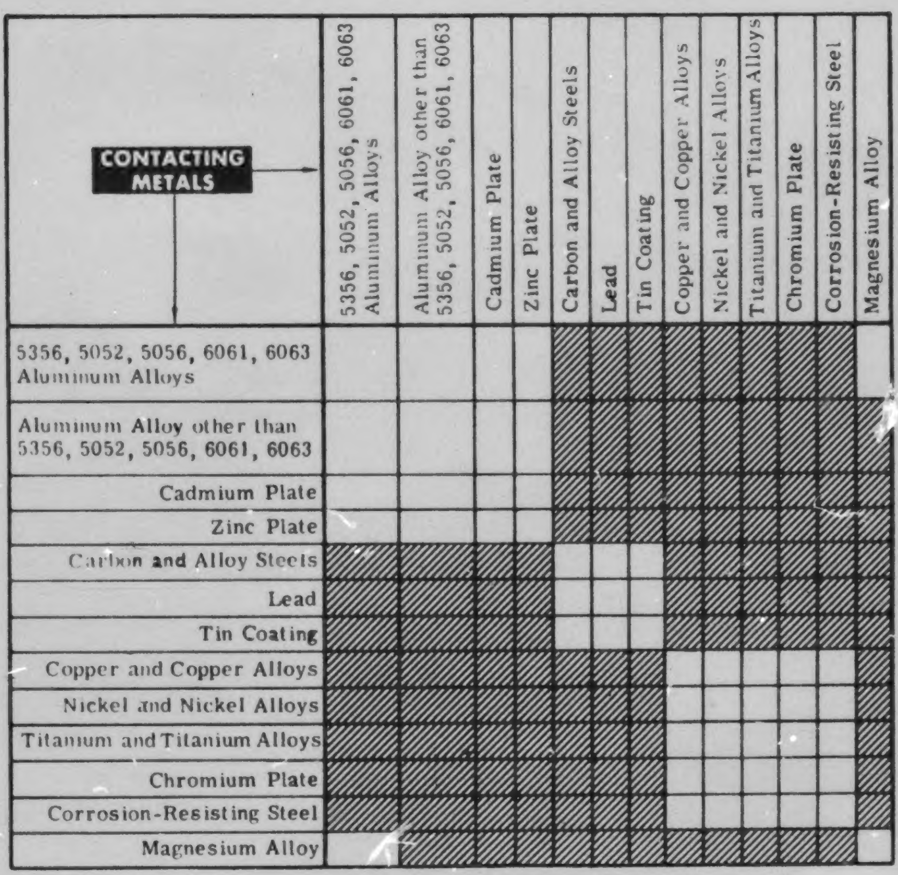
When corrosion protection is the prime reason for plating a base metal, the most common plate metals used are tin, zinc, nickel, chromium, and cadmium. Chromium and nickel are also widely used in such applications as platings on gages, dies, oleo pistons, and cylinder barrels. Resistance to tarnish is provided by gold, nickel, or chromium plating.

Anodizing

Anodizing is the artificial production of a film of hydroxide on the surface of aluminum or any of its alloys. In this process, reactions take place similar to those in electroplating, but this time the controlled oxidation is used to protect the anodic area. The aluminum sheet is made the positive pole. In anodizing the surface, the aluminum sheet combines directly with a source of oxygen to form protective coatings rather than going into solution like the anode in a plating bath. The deposited hydroxide film has good corrosion resisting qualities and is required on most of the aluminum alloys used in the construction of naval aircraft. Without this protective film the aluminum would corrode rapidly when exposed to sea water or to the salty atmosphere close to the sea. This process is not a plating process and therefore has no appreciable thickness to affect the dimensions of the material. The coating is soft and easily scratched, making it necessary to use extreme caution when handling it prior to coating it with primer.

In addition to its corrosion-resisting qualities, the anodic coating is also an excellent bond for paint. In most cases, parts are routed to the paint shop for priming and painting as soon as possible after anodizing. The anodic coating is a poor conductor of electricity; therefore, if parts require bonding, the coating is removed where the bonding wire is to be attached.

Alclad surfaces to be left unpainted require no anodic treatment; however, if the Alclad surface is to be painted, it is usually anodized to provide a bond for the paint.


CONTACTING METALS

	5356, 5052, 5056, 6061, 6063 Aluminum Alloys	Aluminum Alloy other than 5356, 5052, 5056, 6061, 6063	Cadmium Plate	Zinc Plate	Carbon and Alloy Steels	Lead	Tin Coating	Copper and Copper Alloys	Nickel and Nickel Alloys	Titanium and Titanium Alloys	Chromium Plate	Corrosion-Resisting Steel	Magnesium Alloy
5356, 5052, 5056, 6061, 6063 Aluminum Alloys					▨	▨	▨	▨	▨	▨	▨	▨	
Aluminum Alloy other than 5356, 5052, 5056, 6061, 6063					▨	▨	▨	▨	▨	▨	▨	▨	▨
Cadmium Plate					▨	▨	▨	▨	▨	▨	▨	▨	▨
Zinc Plate					▨	▨	▨	▨	▨	▨	▨	▨	▨
Carbon and Alloy Steels	▨	▨	▨	▨				▨	▨	▨	▨	▨	▨
Lead	▨	▨	▨	▨				▨	▨	▨	▨	▨	▨
Tin Coating	▨	▨	▨	▨				▨	▨	▨	▨	▨	▨
Copper and Copper Alloys	▨	▨	▨	▨	▨	▨	▨						▨
Nickel and Nickel Alloys	▨	▨	▨	▨	▨	▨	▨						▨
Titanium and Titanium Alloys	▨	▨	▨	▨	▨	▨	▨						▨
Chromium Plate	▨	▨	▨	▨	▨	▨	▨						▨
Corrosion-Resisting Steel	▨	▨	▨	▨	▨	▨	▨						▨
Magnesium Alloy		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	

Shaded areas indicate Dissimilar Metal Contacts

214.9

Figure 4-2.—Dissimilar metal chart.

PROTECTION OF DISSIMILAR METAL CONTACTS

The use of several types of metals and their alloys in the construction of aircraft requires that some form of protection separator be used to minimize the reaction caused by the differences in electrical potential. Figure 4-2 lists dissimilar metal combinations which require protection separators to prevent corrosion. Separating materials are primers, coatings, plastic tape, washers, grease, or sealant, depending on metals involved.

Grouping of Metals and Alloys

The selection of dissimilar metals that are to be used in contact with each other is generally based on the following activity table:

Group I	Magnesium and its alloys.
Group II	Cadmium, zinc, and all aluminum alloys.
Group III	Iron, lead, tin, and their alloys (except stainless steels).
Group IV	Copper, chromium, nickel, silver, gold, platinum, titanium,

cobalt and rhodium, stainless steels, graphite (including dry film lubricants containing graphite).

This list groups the common metals and their alloys in the order of their electrical potential. Group I materials are the most active metals and the easiest corroded. Group IV materials are the least active and require only minimum protection.

In general, whenever metals from two groups are in contact with each other, special insulation or separator material is used to assure that dissimilar metals corrosion does not take place.

Identification of Metals

In order to provide properly for dissimilar metal contact protection or treat metal surfaces, the structural mechanic needs to be able to identify the type of metal. In most cases this information can be readily obtained from repair illustrations found in the *Structural Repair Manual* for the weapon system being supported, *Maintenance Instructions Manual*, or the appropriate 03 manual for specific components. If this information is not available in reference publications, personnel involved in repairs and corrosion prevention may determine what the materials are by chemical identification methods. Chemical identification of materials

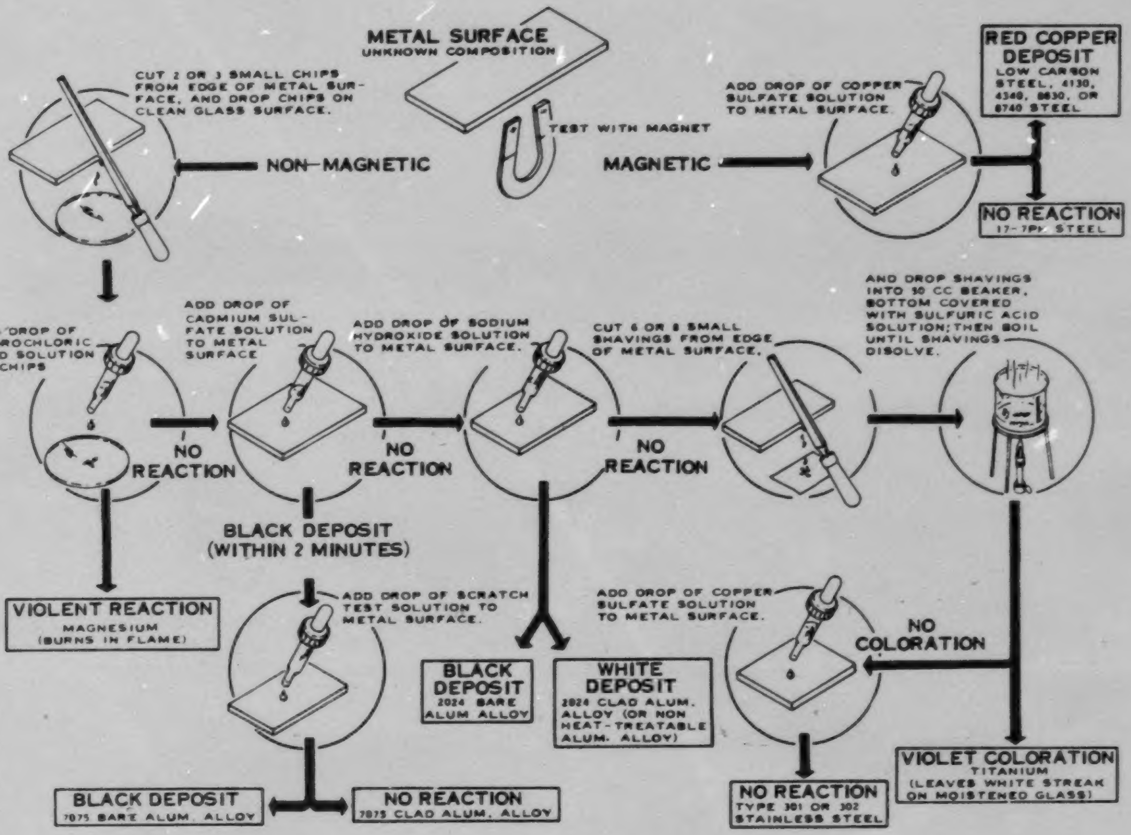

METAL SURFACE
UNKNOWN COMPOSITION
TEST WITH MAGNET
NON-MAGNETIC
MAGNETIC
CUT 2 OR 3 SMALL CHIPS FROM EDGE OF METAL SURFACE, AND DROP CHIPS ON CLEAN GLASS SURFACE.
ADD DROP OF COPPER SULFATE SOLUTION TO METAL SURFACE.
RED COPPER DEPOSIT
LOW CARBON STEEL, 4130, 4340, 8630, OR 8740 STEEL
NO REACTION
17-7PH STEEL
ADD DROP OF HYDROCHLORIC ACID SOLUTION TO CHIPS
NO REACTION
ADD DROP OF CADMIUM SULFATE SOLUTION TO METAL SURFACE
NO REACTION
ADD DROP OF SODIUM HYDROXIDE SOLUTION TO METAL SURFACE.
NO REACTION
CUT 6 OR 8 SMALL SHAVINGS FROM EDGE OF METAL SURFACE.
AND DROP SHAVINGS INTO 10 CC BEAKER, BOTTOM COVERED WITH SULFURIC ACID SOLUTION; THEN BOIL UNTIL SHAVINGS DISOLVE.
VIOLENT REACTION
MAGNESIUM
(BURNS IN FLAME)
BLACK DEPOSIT
(WITHIN 2 MINUTES)
ADD DROP OF SCRATCH TEST SOLUTION TO METAL SURFACE.
BLACK DEPOSIT
2024 BARE ALUM ALLOY
WHITE DEPOSIT
2024 CLAD ALUM. ALLOY (OR NON HEAT-TREATABLE ALUM. ALLOY)
ADD DROP OF COPPER SULFATE SOLUTION TO METAL SURFACE.
NO COLORATION
VIOLET COLORATION
TITANIUM
(LEAVES WHITE STREAK ON MOISTENED GLASS)
BLACK DEPOSIT
7075 BARE ALUM. ALLOY
NO REACTION
7075 CLAD ALUM. ALLOY
NO REACTION
TYPE 301 OR 302 STAINLESS STEEL

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Figure 4-3.—Chemical identification of materials.

will generally have more application within the intermediate level of maintenance for identifying materials used in component manufacture and structural repair.

The chemical identification process illustrated in figure 4-3 is applicable when the material in question is in the following group:

Aluminum or its alloy.
Magnesium or its alloy.
Titanium.
Stainless steel.
Carbon steel.
Low alloy steel.

The test solutions required in figure 4-3 are prepared in the following manner:

1. Copper sulfate solution. Dissolve 25 grams of copper sulfate crystals in 100 cc of distilled water, and add 2 or 3 cc of sulfuric acid.
2. Hydrochloric acid solution. Slowly add 50 cc of hydrochloric acid to 50 cc of distilled water.
3. Cadmium sulfate solution. Mix 5 grams of cadmium sulfate, 5 cc of concentrated hydrochloric acid, and 3 grams of sodium chloride. Dissolve and dilute with water to make 100 cc.
4. Scratch test solution. Dissolve 20 grams of potassium nitrate and 10 grams of sodium hydroxide in 100 cc of distilled water.
5. Sodium hydoxide solution. Slowly add and dissolve 25 grams of sodium hydroxide pellets into 100 cc of distilled water.
6. Sulfuric acid solution. Slowly add 25 cc of sulfuric acid to 75 cc of distilled water.

Personnel should avoid bodily contact with chemicals and solutions. Wash hands with soap and water after handling the container and performing tests. Solutions should be kept in suitable acid–resistant containers and capped tightly when not in use. When mixing solutions, ensure that the sequence of pouring the acid into the water is adhered to as covered in the preceding paragraph.

Preparation of the material to be tested includes removing paint, grease, oil, and other foreign matter from small areas where the chemical solutions are to be applied, and abrading the cleaned areas to remove oxide or protective films and coatings. The test is then accomplished as outlined in Figure 4-3, using a glass tube dropper to apply the solutions.

Immediately after the test is completed, the chemical solutions are removed from the surface with clean cloths and flushed with fresh water. Wet areas on aluminum and its alloys are neutralized with a 5-percent chromic acid solution and flushed with clean water.

Contacts Not Involving Magnesium

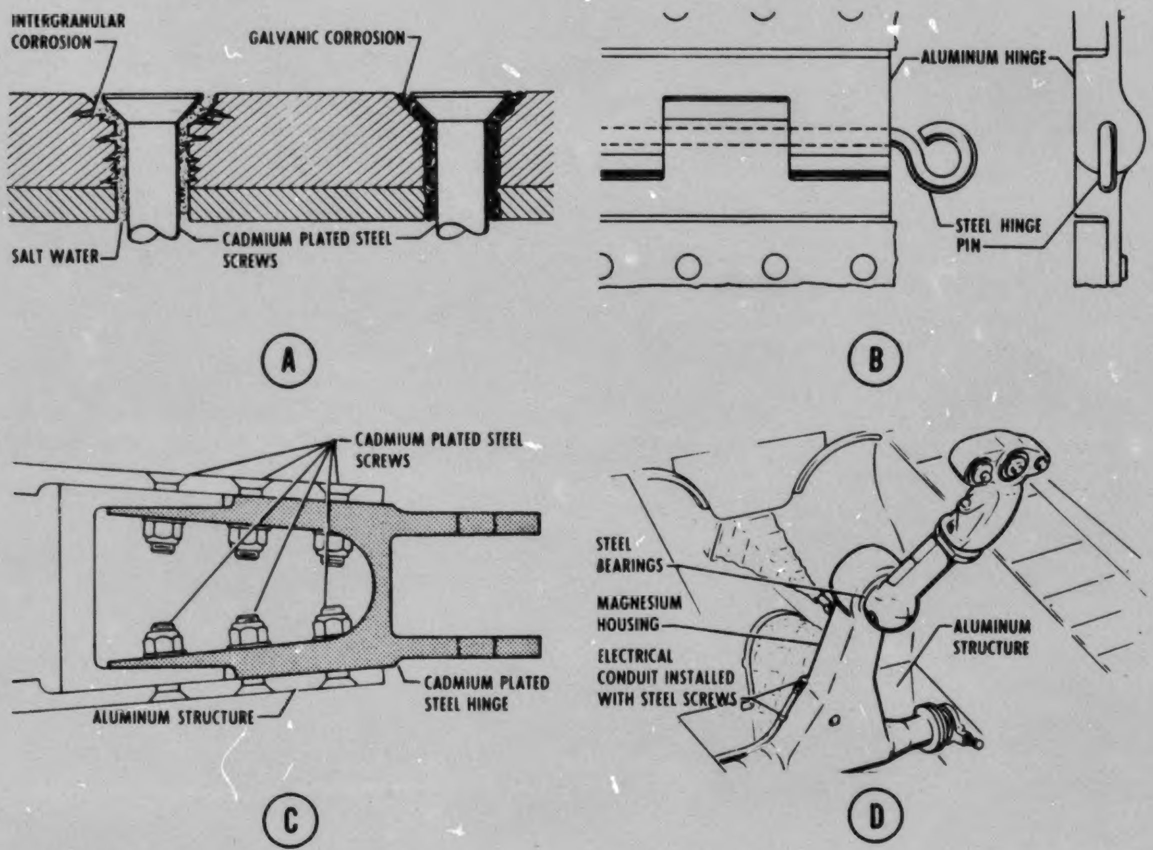
In addition to normal primer requirements, metals indicated to be dissimilar by Figure 4-2 are protected by the application of two coats of primer to both contacting metal surfaces.

Steel bolts, nuts, screws, and some parts of the landing gear are protected against corrosion by an electroplating process called cadmium plating. Other steel parts including the piston section of the landing gear are protected against corrosion by the same type of process called chromium plating. This type of plating is also wear-resistant. Figure 4-4 (A) illustrates dissimilar metals corrosion. Views (B), (C), and (D) show typical installations where this type of corrosion may exist.

Stainless steels develop their corrosion-resistant properties during fabrication by a process known as passivation, which deposits an oxide film on the surface of the metal.

Contacts Involving Magnesium

Magnesium is the most chemically active of all the metals used in aircraft construction; therefore, maximum protection must be used if corrosion is to be prevented. A minimum of two coats of zinc chromate primer is applied to each surface. Next, a layer of organic adhesive or pressure-sensitive vinyl tape is applied for insulation, smoothly and firmly, and it must extend at least one-quarter inch beyond the faying surfaces. Sometimes more than one-quarter inch is required so that water will not bridge over the tape as shown in Figure 4-5. Both kinds of tape will withstand temperatures


INTERGRANULAR CORROSION
GALVANIC CORROSION
SALT WATER
CADMIUM PLATED STEEL SCREWS
A
ALUMINUM HINGE
STEEL HINGE PIN
B
CADMIUM PLATED STEEL SCREWS
CADMIUM PLATED STEEL HINGE
ALUMINUM STRUCTURE
C
STEEL BEARINGS
MAGNESIUM HOUSING
ELECTRICAL CONDUIT INSTALLED WITH STEEL SCREWS
ALUMINUM STRUCTURE
D

214.10

Figure 4-4.—Dissimilar metals corrosion.

up to 300° F. For temperatures between 300 and 500° F, Teflon tape is used.

Insulating washers, made from aluminum alloy with the use of a compound or adhesive backing, are often used on countersunk areas of magnesium panels to reduce the possibility of corrosion between the steel screws and the panels.

IN-SERVICE CORROSION PREVENTION

In-service corrosion prevention refers to the complete program of preventive maintenance directed towards corrosion control. It includes aircraft cleaning, lubrication, inspection and evaluation of damage, treatment, and preservation.

DAILY MAINTENANCE PROCEDURES

Daily maintenance effort directed towards the prevention of corrosion must necessarily be continuous and receive more emphasis during periods when the aircraft are exposed to the severe operating conditions of shipboard operations, overwater flights, and similar environmental conditions.

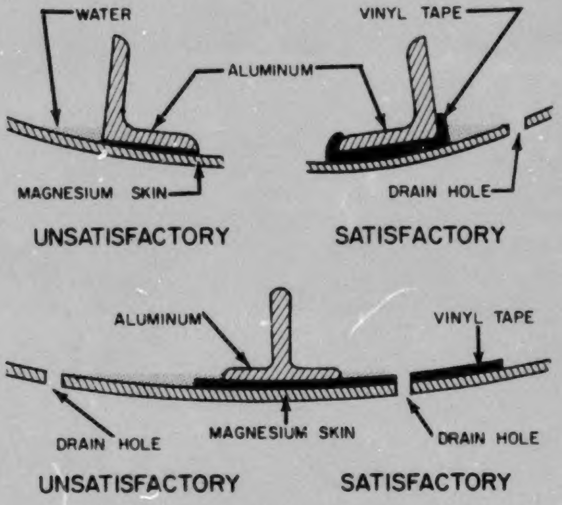


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Figure 4-5.—Use of insulating tape.

Failure of operating activities to properly stress aircraft cleanliness and in-service preservation can result in serious deterioration of the aircraft and develop into a safety of flight situation. It also produces additional workload requirements on rework activities and subsequent aircraft custodians.

Consistent observation by supervisory personnel of the manner in which their subordinates carry out day-to-day maintenance will occasionally reveal work habits which contribute to the susceptibility of the aircraft to its environment by destroying protective finishes. Foot traffic on aircraft surfaces, carelessness in handling tools, parts, and support equipment, plus the failure to utilize available protective pads result in many manhours spent in restoring protective finishes and corrosion removal. Insistence on good work habits always requires continued attention. Conscientious attention to cleaning, ground handling, use of protective pads, covers, and shrouds, and prompt attention to corrosion maintenance discrepancies will result in minimum opportunity for corrosion to take place.

CLEANING REQUIREMENTS AND PROCEDURES

Aircraft cleaning is the first step in the process for prevention of corrosion of aircraft. The general appearance of the aircraft is secondary in importance to the removal of corrosive agents. Not only does cleaning minimize the effects of corrosion caused by contaminants, it also retains aerodynamic efficiency and safety, reduces fire hazards, and helps keep the white coating areas clean enough to serve its purpose of reflecting visible and infrared energy.

Frequency of cleaning will depend upon the type of aircraft and its environment. Cleaning, lubrication, and preservation must be accomplished in accordance with Special or Conditional Maintenance Requirements Cards. Specific effort should be made to clean all corrosion-prone areas at the previously prescribed intervals if unusual conditions prevent complete aircraft cleaning. Magnesium parts, ultrahigh-strength steel parts, engine, rocket and missile exhaust impingement areas, piano hinges, and control cables must be cleaned and inspected on a scheduled basis. In addition, daily cleaning or wipedown is required on all exposed unpainted surfaces such as landing gear struts, acutating rods of hydraulic cylinders, etc. The necessity for additional cleaning is indicated by the evidence of appreciable soil accumulation, excessive oil and exhaust gas deposits, salt deposits, and similar surface conditions. Presence of spilled electrolyte and deposits around battery terminals and general area should get immediate attention. Cleaning is always required after exposure to fire extinguishing materials, severe weather conditions, salt water spray, and low-level ocean flight. After repairs or service, localized cleaning to remove all oil stains, smudges, boot, hand, and finger marks is considered a good maintenance practice and part of the overall job.

In preparing the aircraft for cleaning, all access doors, canopy, air ducts, etc., should be closed or plugged to prevent water entry and damage. Aircraft heated by the sun or as a result of operation should be cooled with fresh water prior to starting cleaning operations. Elevated temperatures can cause rapid solvent evaporation and concentrated solutions which could damage aircraft surfaces. Ensure that all drain holes are clear to prevent the entrapment of cleaning solutions and water.

Most aircraft low-point drains are relatively small holes which are easily blocked with dirt, grease, chips of paint, metal shavings, etc. These drains must be checked daily to ensure that no obstructions are present which will prevent free drainage. They can be kept clear by inserting a probe into the opening. If adequate drain holes are not provided, submit an Unsatisfactory Material/Condition Report (UR).

The *Aircraft Cleaning and Corrosion Control Manual* (NavAir 01-1A-509) provides a complete listing of recommended cleaning materials, types of soil they will effectively remove, and recommended procedures for their use.

All personnel involved in the cleaning of aircraft should have a thorough knowledge of the materials, methods, and procedures used to remove soils from all exposed surfaces.

Suitable equipment should be used and the correct method and sequence of procedures in applying the cleaning agents should be followed. Strict safety regulations and health precautions should be followed in the use and handling of the various cleaning compounds.

NOTE: Aircraft should be provided with a good electrical ground, as cleaning operations produce static electrical charges, creating a fire hazard.

The cleaning procedure used should be the mildest method which will produce the desired result Harsh cleaning methods such as live steam cleaning will remove soils and residual greases, but will also erode paint and damage electrical insulation. High-velocity jets can drive soil and corrosive materials into openings and crevices from which they cannot be removed. For this reason, steam cleaning is no longer authorized for use at the intermediate or organizational levels of maintenance.

Difficulties will be avoided by removing soils as soon as possible. The longer a soil remains in place, the more difficult it is to remove, especially in high temperature areas.

Only the cleaning materials approved by the Naval Air Systems Command can be used on naval aircraft. These cleaners have been approved only after undergoing extensive laboratory tests to prove their ability to clean effectively when mixed at the prescribed concentrations without damaging any of the metallic or nonmetallic materials used in the aircraft.

The approved cleaning materials are, for the most part, nonetching alkaline (soluble and capable of neutralizing acids) type cleaners. Acid cleaners are not approved for use at the intermediate or organizational maintenance levels. Even when used in the proper concentrations, caution must be exercised not to trap any of the cleaning solution in holes, crevices, or overlapping joints, as failure to remove these residual solutions will allow corrosion to occur.

Engine Cleaning and Preservation Procedures (Salt Deposits)

Corrosion team members may be required to assist in performing engine wash and corrosion preventive treatment on certain aircraft engines. Protective coatings on internal parts are subject to erosion by the natural ingestion of abrasive particles such as sand and dirt until the base metal is eventually exposed. Highly stressed areas exposed to corrosion pitting may fail prematurely. Experience has shown that, to maintain top engine performance in all operational environments, the accumulated dirt and salt deposits must be removed.

The differences in engines determine the variations in engine cleaning and preservation procedures. Some engines cannot be washed internally because the water would enter the various systems through their seals. Subsequent engine operation would boil the water away and leave chloride deposits which could rust pumps, bearings, gearboxes, etc., as well as contaminate the lubricants.

Maintenance personnel should always refer to the applicable Maintenance Instructions Manual before washing any engine. Some jet engines such as the T-58/J-79 require washing followed by spraying with a preservative (Rust-Lick #606) into the compressor inlet under the following circumstances:

NOTE: Rust-Lick #606 is a preservative material used specifically for internal engine corrosion prevention.

1. Whenever engine performance deteriorates below allowable limits.
2. Visual inspection reveals a buildup of carbon, dirt, or oil-based deposits on the compressor blades or vanes.
3. Whenever engines have been operated from bases within 10 miles of salt water.
4. All engines operated below 500 feet over salt water and engines that are known to have ingested salt water during hover operations below 30 feet.

Engines that have ingested salt water or mist directly into the compressor inlet should be water-washed and sprayed with preservative after the last flight of the day.

The washing and preservation procedure generally calls for wiping any salt deposits from the compressor inlet and exterior surfaces with a clean water-dampened cloth. The engine is allowed to cool for a specified length of time dependent on the engine. Water is then sprayed into the inlet while motoring the engine. Following the wash with fresh water, excess moisture is wiped from the surrounding skin area and other accessible areas where it may have accumulated. The engine is started and run at ground idle to dry out residual water inside the engine. The engine is allowed to cool again and is then sprayed in much the same manner with Rust-Lick preservative for 3-5 seconds or until the preservative is seen coming from the exhaust casing.

The engine cannot be operated until the Rust-Lick is washed from the compressor by repeating the washing procedure. In colder weather, washing may be accomplished using a mixture of 40 percent methanol and 60 percent water in lieu of plain water. The mixture must be thoroughly agitated prior to spraying. Methanol is flammable and should not be used if the ambient temperature is above 40°F. Its vapor is extremely toxic. If swallowed, methanol can be fatal or cause blindness. Avoid prolonged breathing of vapors and keep it away from open flames.

Postcleaning Requirements

Postcleaning maintenance serves to return the aircraft to a flight ready condition. Cleaning materials, steam from the launching catapults aboard ship, and weather conditions remove lubricants that are essential to safe flight.

Lubrication performs the dual purpose of preventing wear between moving parts and acting as a barrier against corrosive agents by filling the air space between parts and displacing water. The lubrication requirements contained in Maintenance Instructions and on the Maintenance Requirements Cards are usually adequate to prevent corrosion of most lubricated surfaces under normal conditions ashore. However, these requirements should be stepped up, or the lubrication interval shortened, when operating aboard ship or whenever severe operating conditions indicate such action is necessary.

All exposed areas must be lubricated after cleaning. Zerk fitting lubrication points on landing gear, wing fold areas, and other easy-to reach areas are not usually neglected. However, squirt-can type lubrication of hinges, latches and sliding surfaces, and some out-of-the-way flush-type pressure lubrication points are frequently neglected to the point that serious corrosion and structural failures are being experienced.

Certain piano-wire-type hinges, such as those found on access doors, are actuated only when periodic inspections are performed. On inspections, following cleaning and in between the inspection periods, these hinges should receive an application of a water displacing preservative followed by a generous application of preservative type lubricating oil. The hinge should be actuated several times to ensure that the lubricant has thoroughly penetrated all crevices.

When lubricating pressure fittings, make sure that all contaminated grease is forced out and replaced with new lubricant. Excess grease should be wiped from the fitting to prevent dirt accumulation.

Preservatives, sealants, covers, and screws are replaced as applicable and masking materials and protective covers removed. Areas protected by the masking and covers should be spot cleaned.

INSPECTION AND EVALUATION

Inspection for corrosion is a continuing task and should be handled on day-to-day basis. Overemphasizing a particular corrosion problem when it is discovered and then forgetting about corrosion until the next crises are unsafe, costly, and troublesome practices.

Most Periodic Maintenance Requirements Manuals and Maintenance Requirements Cards are complete enough to cover all parts of the aircraft or engine, and no part of the aircraft should go unchecked. Through experience it will be learned that most aircraft have trouble areas where corrosion will set in despite routine inspection and maintenance requirements. These trouble areas may be peculiar to particular aircraft models, but most aircraft operating in a marine environment are found to display similar conditions.

When corrosion is apparent, the extent of the damage must be determined. Evaluation of the damage may be classified as minor damage, significant damage, repairable damage, or damage requiring replacement of the component.

When the extent of the damage has been determined, appropriate action must be taken. Minor damage exists when the protective coatings are scarred or etched by corrosion damage. The corroded surface must be cleaned, treated, and refinished as applicable. Significant damage exists when the damage is within limits of applicable corrosion damage charts and the use of the affected parts may be continued after proper treatment. Repairable damage exists when damage exceeds the limits of applicable corrosion damage charts, and use of the affected parts may be continued after authorized repair. Whenever repair limits are exceeded, the component must be replaced.

Nature and Appearance of Corrosion Products

The ability of maintenance personnel to recognize corrosion products occasionally presents a very real problem. The *Aircraft Cleaning and Corrosion Control Manual*, NAVAIR 01-1A-509, provides descriptive illustrations for the various types of corrosion products. The characteristics of corrosion products for aircraft materials are provided in Table 4-1. The ability to recognize these products will require actual experience.

An adequate description of the nature of corrosion attack on the various aircraft metals is covered in Chapter 11, Rate Training Manual, *AMS 3 & 2*, NAVEDTRA 10308-C.

There are four requirements for corrosion to take place, and all four are required in order for corrosion to occur. There must be an anode, a cathode, a metallic path for conduction of electrons, and a solution capable of conducting an electric current. Removing any one of these will prevent the occurrence of corrosion.

Detecting Methods

Corrosion detection is an integral part of the effort required to prevent corrosion action from spreading. In general, corrosion action begins on the surface of the metal and works to the core. Appearance of the surface or visual detection is therefore the most prominent indication of corrosion. Visual inspection should encompass the following areas:

Inspection of external finishes for scratches, cracks, tears, punctures, peeling, fading, blistering, or other visible damage, particularly around fasteners and in corrosion-prone areas.

Inspect exposed skin edges for condition of protective finish or sealant and for evidence of corrosion.

Inspect interior and exterior areas of known dissimilar metal contact for evidence of corrosion.

Inspect hidden surface areas whenever removal of equipment exposes these areas.

Areas around screws, bolts, and other fasteners should be inspected for corrosion and condition of primers and other protective coatings.

Inspect interior primed surfaces for scratches or other surface wear, with specific attention to interior corrosion-prone areas, including cables.

The nondestructive metal inspection techniques discussed in chapter 5 of this manual are suitable for detection of stress corrosion cracks and intergranular corrosion depth. The more sophisticated methods such as X-ray and ultrasonics require the use of specially trained

Table 4-1.—Corrosion of metals—nature and appearance of corrosion products

Alloy	Type of attack to which alloy is susceptible	Appearance of corrosion product
Aluminum alloy.	Surface pitting, intergranular and exfoliation.	White or gray powder.
Titanium alloy.	Highly corrosion resistant.	Surface cracks.
Magnesium alloy.	Highly susceptible to pitting.	White powdery snowlike mounds and white spots on surface.
Iron-base non-stainless steel (4000-8000 series).	Surface oxidation and pitting, surface and intergranular.	Reddish-brown oxide (rust).
Iron-base stainless steel (300-400 series).	Intergranular corrosion (due to improper heat treatment). Some tendency to pitting in marine environment (300 series more corrosion resistant than 400 series).	Corrosion apparent by rough surface, sometimes apparent by red, brown, or black stain.
Nickel-base alloy (Inconel).	Generally has good corrosion resistant qualities. Sometimes susceptible to pitting.	Green powdery deposit.
Copper base alloy, brass, bronze.	Surface and intergranular corrosion.	Blue or blue-green powder deposit.
Cadmium (used as a protective plating for steel).	Good corrosion resistance. If attack occurs, will protect steel from attack.	White, powdery corrosion products.
Chromium (used as a wear resistant plating for steels).	Subject to pitting attack in chloride environment.	Chromium being cathodic to steel does not corrode itself, but promotes rusting of steel where pits occur in the coating.

operators with experience in interpreting readout presentations.

Water leakage, which could promote corrosion, most often occurs around windows, doors, and access panels. Leaks also occur due to the constant working of airframe surfaces, at points where skins are joined, or where lines and fittings pass through bulkheads. Positive control of water entry requires a continuous schedule of drain maintenance and application of effective methods of sealing potential leak areas. Detection and immediate repair of leaks will materially reduce maintenance requirements at a later date.

Detecting points of water entry may be difficult, especially if water enters at one point and runs along seams, following a diverse course. The use of low-pressure compressed air and a water and detergent solution is effective in pinpointing leakage points. The detergent solution is applied to the exterior surface, and air is applied internally. Any leak should produce sufficient bubbles to be detected. If fresh water is not readily available, a similar procedure of using the compressed air and listening for the hissing sound of the escaping air may be used. Use of a listening device such as a stethoscope or plain hose will eliminate background noise and assist in isolating the point of escaping air. Spraying with fresh water and observing the suspected leak area can also be used, but this method tends to interrupt other maintenance on the aircraft. Whenever the leak is detected, the area must be thoroughly cleaned and dried before resealing.

INSPECTING FOR MICROBIOLOGICAL CORROSION.–Inspection for microbiological corrosion consists of draining samples from the suspected tanks into sterile containers for laboratory analysis. With the aircraft defueled, remove and inspect fuel system filters for abnormal discoloration, rust particles, slime, or fungus deposits. With the tanks still wet, the interior is inspected through access openings, using a vapor-proof flashlight and mirror. After the residual fuel has evaporated, and the tanks are dry, inspect for pinholes, bare areas, blisters, or discoloration. Internal inspection should include all components that are normally immersed in fuel.

The residues of biological contamination are usually green to brown in color and have a slimy texture when wet. If doubt exists as to whether residues are of a biological origin or the usual fuel tank sediment, submit specimens to a laboratory for examination. Removal of these residues may reveal surface or pitting corrosion. If slime or fungus has grown in the tank, minor corrosion damage may also be present on metal surfaces of operational components in the tank.

INSPECTING FOR METALITE (HONEYCOMB) CORROSION.–Metalite exterior surfaces are made up of aluminum separated by a thin metal honeycomb and are highly susceptible to corrosion. A surface bulge may indicate corrosion between the core and the surface. Bulges can be detected by viewing the surface from a low angle or by tapping the surface with a coin or key and listening for the distinctive sound change which would indicate core separation or corrosion damage. Water collection or penetration through defective edge sealants is the most common cause of corrosion in Metalite. Proper inspection and maintenance will be necessary to provide adequate protection.

Corrosion-Prone Areas/ Repair Guides

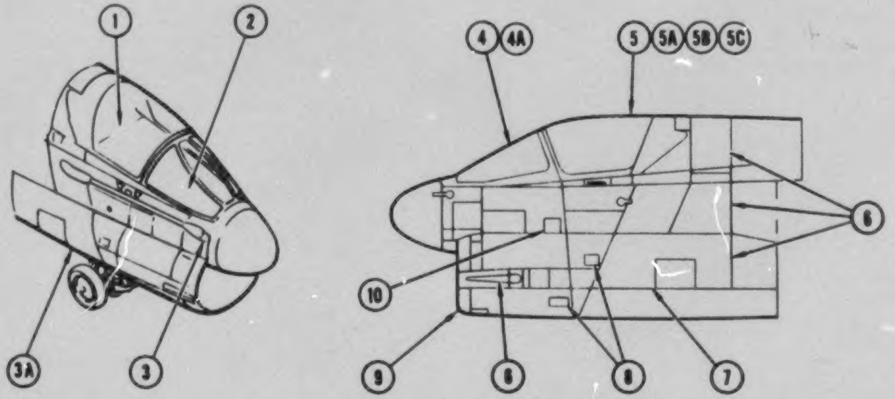
Certain corrosion-prone areas such as exhaust trail areas, engine frontal areas, piano hinges, JATO, rocket, and gun blast areas, battery compartments, lavatories and galleys, bilge areas, wheel well, landing gear, wing fold, flap, and speed brake recesses are considered common to all aircraft and are discussed in chapter 11, the *AMS 3 & 2* Rate Training Manual.

The *Aircraft Cleaning and Corrosion Control Manual,* NAVAIR 01-1A-509, provides descriptions and illustrations of the interior and exterior corrosion-prone areas on most naval aircraft. These areas are covered in greater detail in the specific Aircraft Maintenance Instruction Manuals, Maintenance Requirements Cards, and some Structural Repair Manuals.

It is essential to establish the exact location of magnesium and ultrahigh strength steel parts, engine, rocket, and missile exhaust impingement areas, piano hinges, and control cables. Experience has shown that these areas require more attention than other corrosive-prone areas.

The demand for more emphasis on corrosion is slowly resulting in more specific corrosion maintenance instructions. Figure 4-6 illustrates one manufacturer's attempt to provide that increased emphasis by detailed corrosion-prone area and repair guide sheets for all areas of the aircraft. These sheets pinpoint the area, the type of corrosion attack normally encountered in each area, the probable cause, and the recommended repair action.

MISCELLANEOUS TROUBLE AREAS.–A variety of additional trouble spots exists; some covered by scattered technical directives, others known only from long experience. Most



Index No.	Corrosion-Prone Areas	Type of Corrosion	Probable Cause	Recommended Repair (Refer to repair sections for damage limits, this manual and NAVAIR 01-45AAA-3-2.)
1	Ejection Seat Guide Tracks	Pitting	Worn surfaces and/or scratches	Clean and remove corrosion in accordance with NAVWEPS 01-1A-509. Lubricate tracks with MIL-M-7866 lubricant.
2	Pilot's Floor Assembly	Galvanic and Pitting	Dissimilar metals, trapped water and debris	Clean and strip finish in accordance with NAVWEPS 01-1A-509. Remove corrosion in accordance with NAVWEPS 01-1A-509. Refinish surface as follows: a. Condition surface in accordance with paragraph 1-390, this section. b. Surface treat in accordance with paragraph 1-394. c. Apply MIL-P-23377 epoxy-polyamide primer in accordance with table 1-16 and paragraph 1-422. d. Apply MIL-C-22750 epoxy-polyamide enamel in accordance with table 1-17 and paragraph 1-423.
3	Inflight Refueling Probe Cavity Inflight Refueling Probe Adapter	Galvanic and Pitting	Dissimilar metals, trapped debris, worn surfaces, mechanical damage to surface or finish, and plugged drain holes	Clean and remove corrosion in accordance with NAVWEPS 01-1A-509. Perform repairs as follows: a. Classify damage in accordance with paragraph 1-31, this section.

214.17

Figure 4-6.—Corrosion-prone areas and repair guide (example).

Aviation Structural Mechanics may be able to add a favorite to the following.

Any hose assembly in which internal wire braid is present, located in positions subject to frequent water soakage, requires some type of protective treatment such as protective coatings or sleeves. If a hose assembly has weather-protective coatings or sleeves which are worn through, cracked, or torn so as to expose the hose assembly to corrosion, it must be replaced. The difficulties in determining the extent of deterioration due to corrosion prohibit the reuse of a coated hose.

Trimmed edges of sandwich panels and drilled holes should have some type of corrosion protection. A brushed inhibitor solution treatment or an edge application of sealant, or both, is recommended. All gaps and cavities where potentially injurious materials may be trapped should be filled with sealant. Temporary sealing should be effected immediately if a delay in permanent repair is anticipated.

All cables, whether plain carbon steel or corrosion-resistant steel, should be inspected for condition at each periodic inspection. Pay particular attention to sections passing through bulkheads, fairleads, and around pulleys and grooved bellcrank arms. Should external corrosion be evident, tension should be relieved and the cable checked for corrosion of internal strands. Light external corrosion may be removed and the cable recoated with corrosion preventive compound (MIL-C-16173). Grade 4 is used for interior cables and grade 1 for exterior cables. Do not apply preventive compounds so thick that they will interfere with the motion of cables through fairleads, sheaves, or bellcrank arms.

Cables with moderate to heavy corrosion on external surfaces, cables with corrosion on internal strands, and cables which have broken strands caused by corrosion must be removed and replaced.

In general, the applicable Maintenance Requirements Cards provide a ready means to ensure adequate inspection of all compartments and interior aircraft cavities. When such general requirements are observed along with a periodic check of the common trouble areas, adequate maintenance should be assured for most operating conditions. Frequent reference to the requirements expressed in the *Aircraft Cleaning and Corrosion Control Manual,* NAVAIR 01-1A-509, is recommended to ensure complete and current coverage.

The most effective means of preventing the onset of corrosion is the maintenance of the condition of surface finishes. This may be accomplished by the judicious use of paints, primers, sealants, or preservatives as appropriate. The important thing is that something be done at the earliest practicable moment in order to minimize the continuation and spread of deterioration until more extensive preservation can be accomplished.

AIRCRAFT PRESERVATION

The requirements for preservation of both idle and operating aircraft are detailed in NAVAIR 15-01-500, *Preservation of Naval Aircraft.* These requirements are designed to prevent the deterioration of aircraft and components from any cause.

The susceptibility of an aircraft to corrosion damage is greatest during those periods when the aircraft is inactive or being shipped. Consequently, definite rules for the protection of idle aircraft have been developed which have proven to be capable of preventing deterioration under most storage conditions. They are as follows:

Type A preservation is applied to aircraft awaiting overhaul, conversion, modernization, and strike, and those which have completed their service life. It is also designated for use on aircraft which are in an indefinite storage status or when it is known that the aircraft will be inactive for longer than 6 months. Although type A storage is classified as indefinite storage, effective life is affected by the variations in storage conditions. In most cases outdoor ventilated type storage will be used, and under these conditions representation will be necessary after 3 years. The limitation is imposed primarily by the effective life of barrier materials, sealing tapes, and preservative coatings. If storage is under indoor dehumidified conditions, the storage is considered indefinite and no representation at intervals is required.

Type B preservation is generally applied to serviceable and modernized aircraft that are essentially in a flight ready condition at the time of preservation. Aircraft in this catagory can be stored and maintained in type B preservation for a maximum of 6 months. Type B preservation is ordinarily utilized by Naval Air Rework Facilities or other depot level maintenance facilities. At the end of each 6-month period, aircraft scheduled to return to service without overhaul, rework, or modification are completely depreserved, ground-tested, repaired as necessary, and test flown. If they are scheduled for overhaul, rework, or immediate modification, the test flight may be eliminated.

Type C preservation is used for aircraft to be shipped by ocean surface vessels, trucks, or railroad cars where maintenance facilities and personnel are not available for en route maintenance under type D requirements. Type D may be used in place of type C when specifically authorized. Shipment on low freeboard vessels such as tankers and barges, and cross country open rail and truck shipment where dust, rain, or windstorms are likely to be encountered and ocean shipment when trained maintenance crews are not assigned to accompany and maintain the aircraft requires the use of a complete strippable plastic coating system.

Type D preservation is applied to any operating aircraft that is not flown at least once each 14 days. Type D preservation offers basic protection, with all other procedures being modifications to fit longer or special storage conditions. Aircraft may be maintained in type D preservation for an indefinite period if all discrepancies are corrected promptly and preservation is renewed at the end of each 30-day period. Renewal consists of completely depreserving, ground testing, repair as necessary, and test flight, prior to representation.

Type E preservation (salt water or chemical damage) is performed on aircraft that have crashed in salt or fresh water or have been subjected to fire extinguishing chemicals or foams. For the preservation to be effective, it should be applied as soon as possible after the accident. Essentially, type E preservation consists of removing all traces of corrosive water, salt deposits, or firefighting chemicals, and preserving the cleaned, dried components. It is considered temporary or emergency treatment, and prompt overhaul is necessary to complete the salvage operation and prevent additional damage.

Maintenance of preservative coatings on operating aircraft presents different problems from those involved with idle aircraft. Coatings and finishes are subject to wear, erosion, abrasion, and contamination. Conditions and requirements will vary considerably with land-based aircraft, depending on geographical location and operational commitments.

Under operating conditions, it is frequently necessary to supplement the protection already present on aircraft surfaces, or to provide temporary protection to damaged areas, by the use of various preservative coatings. While any coating of grease or oil is better than leaving a critical metal surface bare, the protection offered by such material is poor when compared to materials strictly compounded for preservation purposes.

For example, a coating of operating hydraulic fluid (MIL-H-5606) will protect a steel panel immersed in water for approximately 48 hours. The same metal panel coated with inhibited hydraulic fluid (MIL-H-6083), which is also red and looks identical to the operating oil, will show 100-percent protection for a period of 30 days or more. The additional protection results from the presence of small amounts of special additives, which form very thin monomolecular films on metal surfaces, that in turn tends to exclude corrosive moisture and oxygen. These inhibiting materials may be added to solid film materials or to oils of various weights and compositions.

Another inhibited preservative which may be used is lightweight lubricating oil, Federal Specification VV-L-800. This material is effective as a short-time protective coating on metal surfaces. It is presently used to lubricate piano hinges on exterior surfaces of aircraft.

It is not intended that preservative coatings should be used as a substitute for good maintenance practices. The "coverup with preservative method" of corrosion treatment is strictly forbidden under current instructions. The only time it is permissible to cover active corrosion with preservative coatings is during actual operations as a temporary measure when the corrosion damage is not extensive enough to cause a detrimental safety-of-flight condition. Complete corrective treatment should be scheduled at the earliest practicable moment consistent with flight operations. Serious corrosive attacks require immediate corrective action. These attacks will usually be evidenced by a buildup of corrosion products which will bubble through preservative coatings. If there is evidence of such a corrosive attack, the affected areas should be thoroughly cleaned of all preservatives, followed by corrosion treatment, protective finish replacement or touchup, and reapplication of the preservative coating.

A brief description of some of the more common preservatives which are readily available in Navy stock is included for information.

·Specification MIL-C-16173 covers two different grades of preservative materials that can be thinned or diluted with drycleaning solvent as necessary, and can be applied by brushing, spraying, or dipping in cold solution.

Grade 1 preservative material forms a hard, dry film for long term protection of metallic surfaces and control cables in accessible areas.

Grade 4 preservative forms thin, semitransparent films through which identification data can usually be read. It also sets up relatively dry to the touch so that preserved parts may be easily handled. This grade is used for protection of control cables in inaccessible or protected areas. It has proved to be particularly effective in protecting wheel well areas and other exposed surfaces where film transparency is required and moderate protective characteristics can be tolerated. The main disadvantages of this material is that it is easily removed by water spray and requires replacement at 1-month intervals under severe exposure conditions.

Corrosion preventive compound MIL-C-81309 is a water-displacing agent which can be used to displace entrapped moisture. Following applications of MIL-C-81309, the area should be protected with Grade 4 preservative.

Sprayable, Strippable Coating Compounds

Activities based outside of the continental United States occasionally receive aircraft from rework activities or the procuring agency via ocean surface shipment. This is especially true of helicopter and limited range fighter aircraft. These aircraft are protected during shipment with a sprayable, strippable coating system, conforming to MIL-C-6799, Type II. Type II coating systems, which are more common to maintenance personnel, are normally applied by spraying and have no harmful effects on metal, plastic, or painted surfaces. They are also useful for protecting transparent acrylic surfaces, such as canopies, against abrasion during maintenance or extended periods of down time.

The type II system consists of a black or black/gray combination base coating and a white topcoating to provide water resistance and solar heat reflectance during outdoor storage. With the black/gray combination base coating, the black material is intended as the base or first coat. The gray material is intended as an intermediate contrasting coat to be applied over the black base coat. However, either color may be applied first depending on the contrast desired. Using the contrasting colors between successive base coats assists in maintaining a uniform film thickness. Nylon ripcords with finger size loops are placed strategically about the aircraft prior to spraying to accommodate the manual stripping of coatings. When properly applied, the coatings can be easily removed. If coatings are sprayed too thin for easy removal, they can be recoated and allowed to dry. The top layer will adhere to previous layers, and all layers may be manually stripped in one operation.

PROTECTION DURING MAINTENANCE AND REPAIR

During any period of inactivity or partial disassembly, it becomes doubly important to observe minimum maintenance requirements. All too often these are periods when protective maintenance is neglected because primary emphasis is directed toward the completion of the repairs.

It is just as important to protect and maintain preservation on aircraft during maintenance and repair periods as it is to protect the aircraft after it is returned to "upstatus." Every precaution should be taken to protect critical surfaces during all stages of maintenance and repair, especially if the work is being accomplished out of doors.

Exposed shafts, splines, and gears should be protected with preservative coatings or general-purpose grease films during all waiting periods. All openings should be kept sealed off until installations are complete. All components that are grease-lubricated in service should be lubricated prior to, or immediately following, installation. All protective coatings damaged during maintenance and repair should be restored; e.g., touch up control cables as necessary. Exposed critical steel parts should be protected with coatings of soft film preservative or general-purpose grease, particularly during outside storage periods. Keep open lines capped off at all times. Take every precaution to avoid marring or destroying chemical finishes on magnesium and aluminum parts. Touch up any scratches on such parts with zinc chromate primer and restore the original finish whenever practicable. Maintain preservative coatings at all times during the work.

CORROSION REMOVAL AND TREATMENT OF AFFECTED AREAS

Complete removal of all corrosion products and damaged metal is of vital importance. Residues and corrosion products which have not been removed can continue to corrode after protective coatings have been reapplied. Corrosion which has been covered in this manner may progress to a critical stage in the strength of the part before it is again detectable by surface inspection. The bottoms of pits and lines of corrosion are frequently very sharp and constitute stress risers, or concentration points. In areas subjected to repeated loading, these discontinuities multiply the effective load around the bottom of the pit or line of corrosion and can cause premature cracking and failure. With this in mind, corrosion removal and treatment of the affected areas become as important as its detection.

PAINT AND DECAL REMOVAL

Paint films are removed by the application of paint thinner whenever possible. Residual paint films may be stripped completely or mechanically abraded to remove loose flaky paint as necessary. Abrasive webbing nylon mat is available in 9 inch by 6 inch sheets in very fine, fine, and medium grits for removing superficial corrosion products and paint scuffing prior to touchup. In all cases the use of abrasive materials such as abrasive sheet material, abrasive-impregnated nylon wheels, abrasive webbing nylon mat, glass vacu-blast beads, etc., should conform to those types of materials listed in NAVAIR 01-1A-509. Use of the proper abrasive materials will minimize the possibility of introducing dissimilar metals which could amplify the possibility of corrosion. Scrapers used in paint removal should be made of nonmetallic material. Improper utilization of equipment can result in the removal of good base metal. The use of carborundum (silicon carbide) sanding paper as a substitute for aluminum oxide paper is prohibited.

The use of paint strippers is preferred only when it is necessary to strip all paint to the bare metal for the purpose of more accurate evaluation of corrosion damage and refinishing procedures. Only the corroded areas should be stripped completely. When restoring deteriorated topcoats, you should strip the lacquer topcoats with a suitable solvent, such as methyl ethyl ketone, rather than strip the complete paint system.

The type of paint finish may be identified by a decal or stencil located on the right side of the aircraft either above or below the horizontal stabilizer.

Materials

Paint removers are toxic and contain ingredients that are harmful to the skin and eyes. It is mandatory that a face shield, rubber gloves, and a chemical-repellent apron be worn while using paint strippers. If removers gets on the skin, immediately flood the affected area with large quantities of water. Rinse freely with diluted alcohol and apply glycerin or petrolatum. If remover gets into the eyes, flood the eyes with water, bathe the eyes with a 3-percent boric acid solution, and add a few drops of U.S.P castor oil. This procedure should always be followed by obtaining medical aid immediately.

Epoxy remover, MIL-R-81294, is effective in removing acrylic and epoxy finishes. Like most removers, it will adversely affect fabrics, fiberglass, acrylic windows, plastic surfaces, and rubber products. The use of solvent-resistant tape and masking materials is required to prevent possible contact with these materials.

Nonphenolic paint and lacquer solvent-type remover, conforming to specification TT-R-248, is recommended for use on enamel, acrylic nitrocellulose, and cellulose nitrate paint systems.

Fluorescent paint remover, MIL-R-21972, is an alkali-organic solvent-type remover recommended for use in removing camouflage, fluorescent, and wax coatings from aircraft.

Paint remover, conforming to MIL-R-18553, is used where contact with synthetic rubber is unavoidable.

Paint strippers must not be used on structural fittings such as wing spars, landing gear, etc., due to the possibility that such acid-type removers may cause hydrogen embrittlement and subsequent part failure.

Stripping Procedures

Paint removers are in liquid form, semiviscous, nonflammable, and water rinsable. They may be used as received and are applied by dabbing with a brush. Removers are subjected to aging and therefore should not be stored in large quantities in excess of immediate needs.

General use of removers includes the masking of all areas where contact with the remover is not desired. Care must be taken around sealant seams, since the stripper will tend to soften and deteriorate the sealant and allow the ingress of water, electrolyte, and other corrosive contamination. Apply the stripper to the area being refinished, using a dabbing action. Brushing tends to decrease the softening ability of the stripper. Allow the stripper to remain in place until the paint film is softened or lifted, as indicated by its wrinkled appearance. Scrub the surface with a brush or nonmetallic scraper to loosen any paint as necessary. Additional saturation with remover may be required where the paint remains tight or where the stripping material has dried.

The residual stripper and loosened paint are removed by washing and scrubbing the surface with a low to medium pressure spray of water. The area is then cleaned with approved cleaners and the masking materials removed. The use of nonmetallic scrapers or abrasive webbing pads is approved for removing persistent paint finishes.

Generally, decals will be affected by the action of the previously mentioned strippers and solvents; however, other methods may be required for their complete removal. Decals can be loosened by the application of heat, using radiant heat lamps or a hot air gun. The edge of the decal is lifted, using a beveled micarta or Plexiglas scraper and then manually pulling the decal off. Any adhesive remaining on the surface can be dissolved and removed with a solution of 75-percent toluene and 25-percent isopropyl alcohol, methyl ethyl ketone, or methyl isobutyl ketone. Use of heating devices in fuel cell areas is prohibited. Alternate methods of removing decals in these areas include the use of suitable strippers, such as Pennsalts E-Z Strip 19A or equivalent. Several coatings are applied to the decal and allowed to set for 20 to 30 minutes. The decal will loosen enough to be manually stripped from the surface. Remaining adhesive can be removed in the same manner as for other removal methods.

CORROSION PRODUCT REMOVAL

After the paint has been removed from corroded areas, it is necessary to remove all corrosion products before an accurate evaluation of the extent of damage can be made. The corrosion removal procedures for the various aircraft metals are discussed in the following paragraphs. Corrosion removal procedures are covered in detail in the *Aircraft Cleaning and Corrosion Control Manual,* NAVAIR 01-1A-509. In the event of conflict between the corrosion control volume of the Maintenance Instructions Manual for a specific aircraft and NAVAIR 01-1A-509, the latter will take precedence.

Corrosion products are always removed by the mildest method available. Mechanical methods have proven best suited in minimizing the removal of sound metal and avoiding surface damage. High-speed grinders and sanders are prohitited because they can damage parts by removing sound metal and concentrating heat and stress.

Mild to medium corrosion is removed by vacu-blasting with abrasive glass beads (MIL-A-9954) only. This method has proven most effective in removing corrosive residues on irregular surfaces and pitted areas. The Vacu-Blast Dry Honer is described and illustrated in chapter 11, *AMS 3 & 2*, NAVEDTRA 10308-C.

Small areas of mild to medium surface corrosion are removed with aluminum oxide abrasive paper, 300-400 grit, or aluminum oxide nylon webbing.

In areas where corrosion is severe, removal is accomplished using an air-driven drill motor and an aluminum oxide abrasive-bonded nylon wheel if skin thickness is greater than 1/16 inch.

Removing Exfoliation Type Corrosion

Exfoliation type corrosion is the result of intergranular attack in which separation and lifting of metal layers occur. It is the hardest type to detect in its early stages. It is usually first evident as small raised areas or bumps under the paint film. As attack progresses, corrosion products break the paint film, and separated layers of metal become visible. Removal of all visible exfoliated metal frequently exceeds the allowable corrosion damage limits. Critical areas should be evaluated by competent authority to prevent flight hazards.

Removal of exfoliated metal is accomplished using abrasive impregnated nylon wheels. Vacu-balsting is not considered satisfactory but is permissible for final cleanup of the corroded area. When all the products of corrosion are removed, exposed edges should be blended and polished to accommodate refinishing procedures.

Depressions resulting from corrosion removal are cleaned, chemically treated, rinsed, and air dried. The depression is then filled with MIL-S-8802 sealant and faired with the surrounding surface. The scraper used to smooth the sealant will be easier to use if it is dipped in water prior to making the final fairing strokes.

Corrosion Removal Around Fasteners

Corrosion removal around fasteners is difficult without removing the fasteners. However, permanent fasteners must not be removed, unless specific approval is granted. Corrosion is removed by vacu-blasting, or other mechanical means, with care being taken to minimize the removal of cadmium plating from the fasteners. If replacements are available, corroded removable-type fasteners should be replaced.

Anodized Surfaces

The oxide film provided by anodizing aluminum offers natural protection against corrosive attack. When this film is damaged in service, it can only be partially restored by chemical surface treatment.

Abrasive-impregnated nylon webbing is adequate for corrosion removal. Additonal care should be exercised to avoid unnecessary removal of protection. Following corrosion removal, the anodized surface must be cleaned, chemically treated, rinsed thoroughly, and allowed to dry before reapplying a complete touchup paint system. Touchup painting is covered later in this chapter.

Unpainted (Clad) Aluminum Surfaces

Unpainted aluminum sheets with pure aluminum (clad) coatings offer greater resistance to corrosion than unclad or bare aluminum alloys. Due to the harsh environment that most naval aircraft are subjected to, unpainted clad surfaces are becoming rare. Care must be exercised to prevent staining and marring, and minimize removal of the protective layer. Oil and surface dirt are removed with water emulsion cleaner, and corroded areas are hand-polished with metal polish conforming to MIL-P-6888. This polish removes stains and light surface corrosion and provides a high, lasting polished finish. It is not recommended for use on anodized surfaces. Polished clad may be coated with waterproof, solvent-type aircraft wax to provide additional protection.

Corrosion Removal from Magnesium

Some magnesium parts in current aircraft have been originally protected by a proprietary electrolytic process. The DOW 17 electrolytic coating has a green to grayish green color. The HAE process is identifiable by its brown to mottled gray appearance. Electrolytic-type coatings provide thicker protective coatings than brush- or dip-type coatings. These finishes cannot be restored in the field, and care should be taken to minimize their removal.

Corroded areas are cleaned and stripped, and corrosion removed by using abrasive-impregnated nylon webbing and vacu-blasting with abrasive glass beads. The paint edges around the corroded area are feathered and the area recleaned with water emulsion cleaner. The area is then rinsed thoroughly with fresh water. With the surface still wet, chemical surface treatment, MIL-C-81706, is brushed on until the metal is a uniform light brown color. This surface treatment is the same as that used for pretreating aluminum. The solution is mixed in the same manner as recommended for aluminum; however, the reaction will be much faster on magnesium. The treatment solution is rinsed off thoroughly, using fresh water, and the surface allowed to air dry. Depressions are filled with sealant and appropriate finishes of epoxy primer and acrylic lacquer topcoat applied.

Corrosion Removal From High Strength Steel

The only approved method of removing corrosion from high-strength steel parts is by vacu-blasting with glass beads, or hand methods using a fine grit abrasive-impregnated nylon webbing or 300-400-grit aluminum oxide paper. Power-driven tools are emphatically prohibited.

Stainless Steels

Stainless steels have corrosion resistance due to oxide films formed by passivation at the time of manufacture. Exposure to abrasion and atmospheric conditions cause these films to break down over prolonged periods. Corrosion treatment is limited to cleaning with P-D-680, solvent drycleaner, followed by hand corrosion removal with abrasive-impregnated nylon webbing and cleaning with water emulsion cleaning solution.

Titanium Alloys

Titanium is highly corrosion-resistant, but it may show deterioration from the presence of salt deposits and other contaminants, particularly at elevated temperatures.

When titanium surfaces require cleaning and corrosion treatment, the same procedure used for stainless steel is utilized.

Copper Alloys

Corrosion attack on copper alloys is usually limited to superficial staining and tarnish. Neither is considered damaging and should ordinarily have no effect on the function of the part. Stains and tarnish can be removed by using a 10 percent solutin of citric acid as a brightener bath. The part can be immersed in the solution or treated in place by brush application of the solution. Care must be taken to prevent solution entrapment. Following application, the part should be thoroughly rinsed with fresh water to remove all residual solution.

Metal Coatings

Silver, gold, platinum, nickel, and chromium are used in aircraft because of their electrical characteristics or wear-resistant qualities. Chromium and nickel wear-resistant coatings (plating) protect underlying metal by forming a physical barrier. Breaks in the coating destroy protection. Tarnish or discoloration can be removed with MIL-P-6888, aluminum polish. When plating on a part fails, the underlying metal should be mechanically cleaned and temporary protective coatings applied until the part can be repaired or replaced.

MECHANICAL CORROSION REMOVAL BY BLASTING

One approach to more complete removal of corrosion products on assembled aircraft is the use of portable vacu-blast equipment.

Specialized training and licensing for the use of power tools and the vacu-blast machine are required for at least four rated structural mechanics in each operating squadron.

The Vacu-Blast Aero Dry Honer is a portable self-contained lightweight unit utilizing the dry vacuum return system. It is the only authorized blasting method of removing corrosion on assembled aircraft. With this machine the work is more visible, and metal removal can be held to closer limits. The machine is air-operated and can be used in shore-based or shipboard operations.

Since the Vacu-Blast Aero Dry Honer is described and illustrated in detail in *AMS 3 & 2,* NAVEDTRA 10308-C, chapter 11, no further information on this subject is presented here.

CORROSION DAMAGE LIMITS

Corrosion, however slight, is damage and must be treated as such. The amount of metal removed detracts from the overall margin of safety built into the aircraft by the manufacturer. The amount of base metal removed must be measured and compared with allowable limits established by the manufacturer and published in corrosion control volumes of specific Maintenance Instructions Manuals and Structural Repair Manuals. Limits for major, primary, and secondary structures are generally found in the Structural Repair Manual. Limits for certain components are published in the corrosion volume of the Maintenance Instructions Manual. Complete evaluation and classification of the damage as superficial or negligible, significant, repairable, or damage requiring replacement will require mature judgment based on information provided in both manuals. Requests for evaluation by engineering personnel or higher authority may be necessary.

Where corrosion damage limits have not been published, use 80 percent of the mechanical damage limits in applicable aircraft publications and report this lack of information on an Unsatisfactory Material/Condition Report, UR.

CHEMICAL SURFACE TREATMENT

Chemical conversion coatings are used to increase corrosion resistance and improve adhesion of subsequent coatings. After cleaning and removal of surface oxides, aluminum surfaces should be treated with MIL-C-81706 chemical film.

The complete procedure for using MIL-C-81706 consists of ensuring that the surface is clean, followed by brush applications of the chemical soltuion. Repeated application of fresh solution will produce a uniform coating with an iridescent yellow to brown color. The area is then rinsed and allowed to air dry. A powdery film coating indicates poor rinsing or failure to keep the surface wet during the treatment. Should this occur, retreatment is necessary.

The soluble salt residue remaining on the surface after use of MIL-C-81706 will accelerate corrosion and can cause blistering of paint finishes if it is not rinsed thoroughly. Rinse with fresh water and allow the surface to air dry. Wiping to dry the surface is prohibited, as the chemical film is easily damaged by the abrasive action of wiping prior to initial drying. Air drying will usually take 1 hour, dependent on temperature and humidity.

On magnesium alloys, apply the conversion coating material MIL-M-3171 until a greenish-brown or brass-colored yellow is obtained. For a proper conversion coating, keep the surface wet with a specified solution until the desired color is obtained. For magnesium alloys, rinsing is not necessary, although it is desirable. No damage will occur if the magnesium conversion coating material is not rinsed.

These conversion coatings are easily damaged during aircraft maintenance or when they are contaminated by grease, oil, and other foreign matter. Once the area is treated, it should be painted as soon as practicable after the surface has air-dried.

CAUTION; Chemical film materials are strongly oxidizing and are a fire hazard in contact with organic materials such as paint thinners. Do not store or mix surface treatment materials in containers previously containing flammable products. Rags contaminated with chemical film material should be burned as soon as practicable.

AIRCRAFT AND COMPONENT PAINTING AND TOUCHUP

At the organizational and intermediate levels of maintenance, touchup for all types of paint systems is identical. Use epoxy primer, MIL-P-23377, topcoated with acrylic lacquer, MIL-L-83152. This touchup systems is compatible with all present paint systems.

The adequacy of aircraft and component paint coatings should be based on their corrosion-protection ability, not their appearance. The practice of overspraying for eye-appeal is prohibited because of the potential for intercoat adhesion failures and the covering up of corrosion. Manhours expended for unnecessary painting can be used more effectively for corrosion prevention, removal, and touchup of actual corroded areas.

Senior AMH personnel supervising corrosion maintenance should ensure that only approved materials, equipment, and procedures are used when painting aircraft and components. Paint procedures, materials, and equipment are adequately covered in Chapter 11, *AMS 3 & 2,* NAVEDTRA 10308-C, and therefore not repeated here.

CHAPTER 5

NONDESTRUCTIVE INSPECTION OF METALS

Nondestructive inspection (NDI) of metal is a general term applied to a variety of methods used to determine the integrity of aircraft structures and components without adversely affecting the usefulness of the structure or component.

Aircraft parts are subjected to repeated stresses and in some instances overstress, which can result in fatigue failure. Failures can generally be related to design deficiency, material failure, or accidental overstress. The nondestructive inspection methods covered in this chapter serve as tools of prevention which allow defects to be detected before they develop into serious failures.

MAGNETIC PARTICLE INSPECTION

Magnetic particle inspection is a method of detecting invisible cracks and other defects in magnetic materials. The method is specifically applicable to ferromagnetic metals such as iron and low-carbon steels, which can be easily magnetized. Magnetic particle inspection has proved extremely reliable for the rapid detection of defects on or near the surface. In using this method of inspection, the location of the defect is indicated and the approximate size and shape are outlined.

The inspection process consists of magnetizing the part and then applying ferromagnetic particles to the surface of the part. If a discontinuity is present, the magnetic lines of force will be disturbed and opposite poles will exist on either side of the discontinuity. The magnetized particles thus form a pattern in the magnetic field between the opposite poles. This pattern, known as an "indication," assumes the approximate shape of the surface projection of the discontinuity.

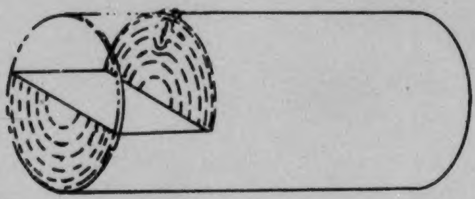
The ferromagnetic particles (indicating medium) may be held in suspension in a liquid that is flushed over the part, the part may be immersed in the suspension, or the particles, in dry powder form, may be dusted over the surface of the part. The wet process is more commonly used in the inspection of aircraft parts.

NOTE: A discontinuity may be defined as an interruption in the normal physical structure or configuration of a part such as a crack, forging lap, seam, inclusion, porosity, and the like. A discontinuity may or may not affect the usefulness of a part.

DEVELOPMENT OF INDICATIONS

When a discontinuity in a magnetized material is open to the surface and a magnetic substance in the form of an indicating medium is available on the surface, the flux leakage at the discontinuity tends to form the indicating medium into a path of higher permeability. Permeability is a term used to refer to the ease with which a magnetic flux can be established in a given magnetic circuit. Because of the magnetism in the part and the adherence of the magnetic particles to each other, the indication remains on the surface of the part in the form of an approximate outline of the discontinuity that is immediately below it.

The same action takes place when the discontinuity is not open to the surface, but since the amount of flux leakage is less, fewer particles are held in place and a fainter and less sharply defined indication is obtained.



216.3

Figure 5-1.—Flux leakage at transverse discontinuity.

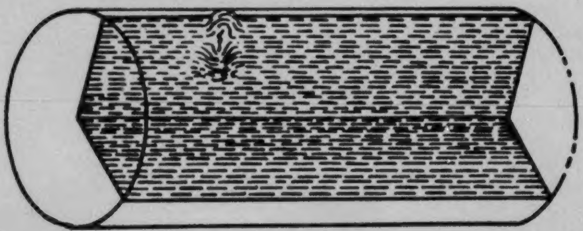
If the discontinuity is very far below the surface, there may be no flux leakage and therefore no indication on the surface. The flux leakage at a transverse discontinuity is shown in figure 5-1. The flux leakage at a longitudinal discontinuity is shown in figure 5-2.

TYPES OF DISCONTINUITIES DISCLOSED

The following types of discontinuities are normally detected by the magnetic particle test: cracks, laps, seams, cold shuts, inclusions, splits, tears, pipes, and voids. All these may affect the reliability of parts in service.

Cracks, splits, bursts, tears, seams, voids, and pipes are formed by an actual parting or rupture of the solid metal. Cold shuts and laps are folds that have been formed in the metal, interrupting its continuity.

Inclusions are foreign material formed by impurities in the metal during the metal processing stages. They may consist, for example, of bits of furnace lining picked up during the melting of the basic metal, or of other foreign constituents. Inclusions interrupt the continuity of the metal because their presence prevents the joining or welding of adjacent faces of the metal.



216.4

Figure 5-2.—Flux leakage at longitudinal discontinuity.

PREPARATION OF PARTS FOR TESTING

All parts must be cleaned of grease, oil, and dirt before they are tested. Cleaning is important, since any grease or other foreign material present may produce nonrelevant indications by reason of magnetic particles adhering to the foreign material as the suspension drains from the part.

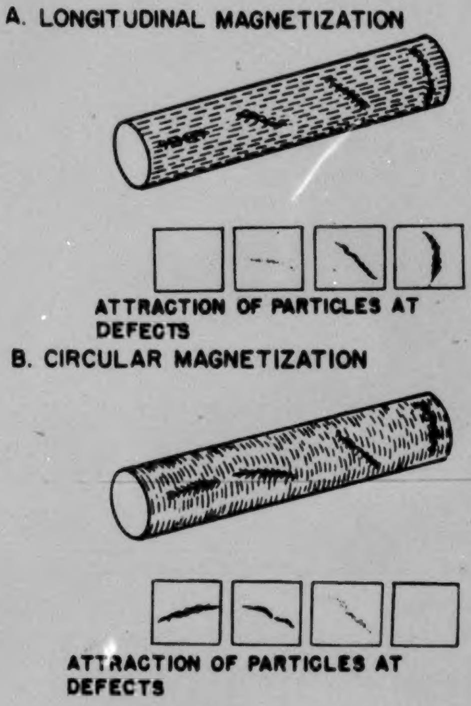
Grease or foreign material in sufficient amount over a discontinuity may also prevent the formation of a pattern at the discontinuity. It is not advisable to depend upon the magnetic particle suspension to clean the part. Cleaning by the suspension will not be thorough, and the foreign materials removed from the part will contaminate the suspension and reduce its effectiveness.

In the dry procedure, thorough cleaning is very necessary as grease or other foreign material will hold the magnetic powder, causing nonrelevant indications and making it impossible to evenly distribute the indicating medium over the surface of the part.

All small openings and oil holes leading to obscure passages or cavities should be plugged with paraffin or other suitable nonabrasive material.

Primers, paints, enamels, and similar nonmetallic coatings, as well as coatings of cadmium, copper, tin, and zinc do not interfere with the satisfactory performance of magnetic particle inspection, unless the coatings are unusually heavy, or the discontinuities to be detected are unusually small.

Chromium and nickel plating will not generally interfere with the formation of indications of cracks open to the surface of the base metal, but will prevent the formation of indications of fine discontinuities, such as inclusions. Because it is more strongly magnetic, nickel plating is more effective than chromium plating in preventing the formation of indications.


A. LONGITUDINAL MAGNETIZATION
ATTRACTION OF PARTICLES AT DEFECTS
B. CIRCULAR MAGNETIZATION
ATTRACTION OF PARTICLES AT DEFECTS

216.5

Figure 5-3.—Effect of direction of flux on strength of indication.

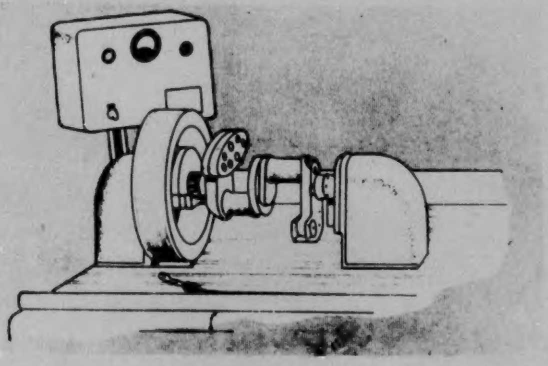
MAGNETIZATION

EFFECT OF DIRECTION OF FLUX (LINES OF FORCE)

In order to locate a defect in a part, it is essential that the magnetic lines of force pass approximately perpendicular to the defect It is therefore necessary to induce magnetic flux in more than one direction since defects are likely to exist at any angle to the major axis of the part. This requires two separate magnetizing operations, referred to as circular magnetization and longitudinal magnetization. The effect of direction of flux is illustrated in figure 5-3.

Circular Magnetization

Circular magnetization is the inducing of a magnetic field consisting of concentric circles of force about and within the part by passing electric current through the part. This type of magnetization will locate defects running approximately parallel to the axis of the part.

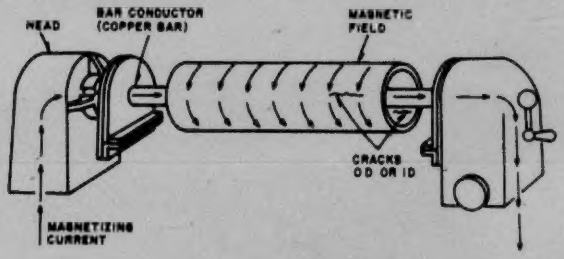


216.6

Figure 5-4.—Circular magnetization of crankshaft.

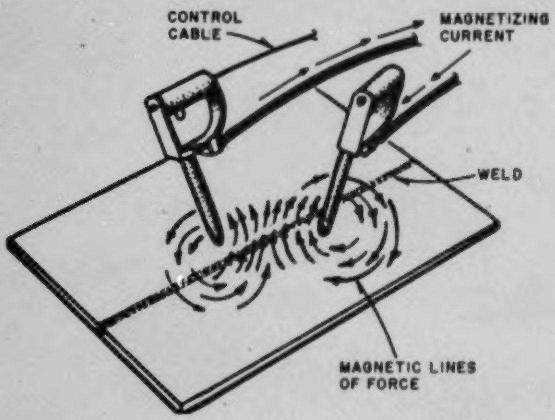
Circular magnetization of a part of solid cross section is illustrated in figure 5-4. Each head of the magnetizing unit is electrically connected to a pushbutton control, so that when contact is made the magnetizing current passes from one head to the other through the part.

Electric currents passed through hollow or tubelike parts circularly magnetize them but do not produce satisfactory magnetic fields on the inside surfaces. Satisfactory fields can be induced by sliding the part onto a conductor.


HEAD
BAR CONDUCTOR (COPPER BAR)
MAGNETIC FIELD
CRACKS OD OR ID
MAGNETIZING CURRENT

216.7

Figure 5-5.—Conductor used to circularly magnetize a cylinder.



216.8

Figure 5-6.—Circular fields produced in sheet weld by electric current passed between contact prods.

Current passes through the conductor and induces circular magnetic fields on both inside and outside cylindrical surfaces as illustrated in figure 5-5.

Circular fields can also be induced in localized areas of parts by using cables and probes or contacts to pass current through the area being inspected as illustrated in figure 5-6.

Longitudinal Magnetization

In longitudinal magnetization the magnetic field is produced in a direction parallel to the long axis of the part. This is accomplished by placing the part in a solenoid excited by electric current. The metal part then becomes the core of an electromagnet and is magnetized by induction from the magnetic field created in the solenoid.

In longitudinal magnetization of long parts, the solenoid must be moved along the part in order to magnetize it in appropriate lengths. (See fig. 5-7.) This is necessary to ensure adequate field strength throughout the entire length of the part.

Solenoids produce effective magnetization for approximately 6 to 9 inches from each end of the coil. When inspecting a long part, it will be necessary to magnetize and inspect it in sections along the entire length of the part.

Longitudinal magnetization equivalent to that obtained by a solenoid may be accomplished by wrapping a flexible electrical conductor around the part, as shown in figure 5-8. Although this method is not as convenient, it has the advantage that the coils conform more closely to the shape of the part, thus producing somewhat more uniform magnetization. The flexible coil method is also useful for large or

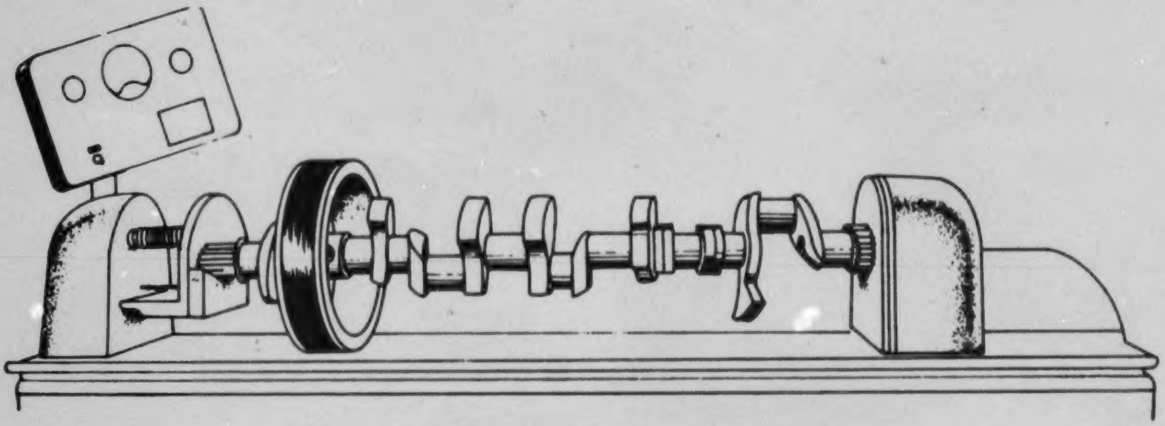


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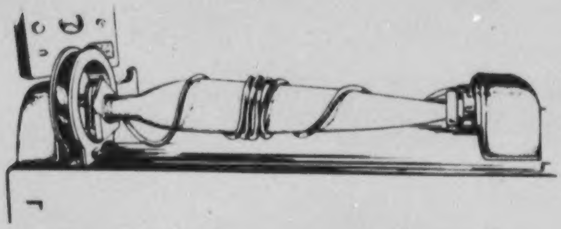
Figure 5-7.—Longitudinal magnetization of crankshaft. (Solenoid method)



216.10

Figure 5-8.—Longitudinal magnetization of steel propeller blade. (Cable method.)

irregularly shaped parts for which standard solenoids are not available.

A longitudinal magnetic field can be induced in a part, or in an area of a part, by means of a yoke. This yoke is a "C"-shaped piece of soft magnetic material, either solid or laminated. A coil is wound around the yoke which carries the magnetizing current.

When a part is placed across the opening of the "C" and the coil is energized, the part completes the path of the magnetic lines of force and sets up a longitudinal field in the part between the ends of the "C". The Parker Contour Probe discussed later in this chapter illustrates the practicality of this method of magnetizing parts.

Specially designed equipment is also available for the simultaneous application of two or more magnetizing currents to parts. This equipment sets up a swinging field and eliminates the time-consuming process of magnetizing the part in different directions to ensure that all defects are discovered.

EFFECT OF FLUX DENSITY

The effectiveness of the magnetic particle inspection also depends on the flux density or field strength that exists at the surface of the part when the indicating medium is applied. As the flux density in the part is increased, the sensitivity of the test increases because of the greater flux leakages at discontinuities and the resulting improved formation of magnetic particle patterns.

Excessively high flux densities, however, may form nonrelevant indications; for example, patterns of the grain flow in the material. These indications will tend to interfere with the detection of patterns resulting from significant discontinuities. It is therefore necessary to use a field strength high enough to reveal all possible harmful discontinuities, but not strong enough to produce confusing nonrelevant indications.

Recommended values for most parts are 800 to 1,000 amperes for each inch of cross section. For example, if a cylindrical part is 1 inch in diameter, an amperage of 800 to 1,000 should be passed through the part.

MAGNETIZING METHODS

When a part is magnetized, the field strength in the part increases to a maximum for the particular magnetizing force and remains at this maximum as long as the magnetizing force is maintained.

When the magnetizing force is removed, the field strength decreases to a lower residual value, depending on the magnetic properties of the material and the shape of the part. These magnetic characteristics determine whether the continuous or residual method is used in magnetizing the part.

Continuous Method

In the continuous inspection method, the indicating medium is on the part while the magnetizing current is flowing. The available flux density in the part is thus at a maximum. The maximum value of flux depends directly upon the magnetizing force and the permeability of the material of which the part is made.

When using the wet continuous method, the indicating medium bath is liberally applied to all surfaces of the part. The instant that the bath stream is removed from the part, the magnetizing force is applied; this ensures that the indicating medium will be on the part while the current is flowing so the particles can be attracted to any leakage fields created by discontinuities. If the wet bath is applied during or after the magnetizing force, there is a possibility that the force of the bath stream may wash off lightly held indications.

When the dry continuous method is used, the part is magnetized using probes, clamps, or a coil. While the current is flowing, the powder is applied to the magnetized area in a light cloud and the excess powder is blown off with low-pressure air. After the excess powder is removed, the magnetizing current is shut off.

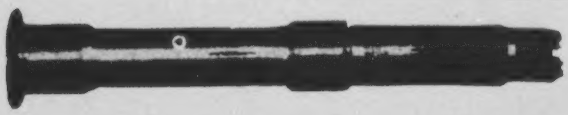
The continuous procedure provides greater sensitivity than the residual procedure, particularly in locating subsurface discontinuities. The highly critical nature of aircraft parts and assemblies and the necessity for subsurface inspection in many applications have resulted in the continuous method being more widely used by naval air activities.

Inasmuch as the continuous procedure will reveal more nonsignificant discontinuities than the residual procedure, careful and intelligent interpretation and evaluation of discontinuities revealed by this procedure are necessary.

Residual Method

The residual inspection procedure involves magnetization of the part and application of the indicating medium after the magnetizing force has been removed. This procedure relies on the residual or permanent magnetism in the part and is more practical than the continuous procedure when magnetization is accomplished by flexible coils wrapped around the part. However, it must be remembered that residual fields are always weaker than magnetic fields which are present when the current is flowing. Consequently, inspection with the residual method will not be as sensitive as with the continuous method.

In general, the residual procedure is used only with steels which have been heat-treated for stress applications.



216.11

Figure 5-9.—Fatigue crack in crankshaft.

IDENTIFICATION OF INDICATIONS

The correct evaluation of the character of indications is extremely important, but is sometimes difficult to make from observation of the appearance of the indications alone. The principal distinguishing features of indications are shape, buildup, width, and sharpness of outline. These characteristics, in general, are more valuable in distinguishing between types of discontinuities than in determining their severity. However, careful observation of the character of the magnetic particle pattern should always be included in the complete evaluation of the significance of an indicated discontinuity.

Cracks

The most readily distinguished indications are those produced by cracks open to the surface. These discontinuities include fatigue cracks, heat-treat cracks, shrink cracks in welds and castings, and grinding cracks.

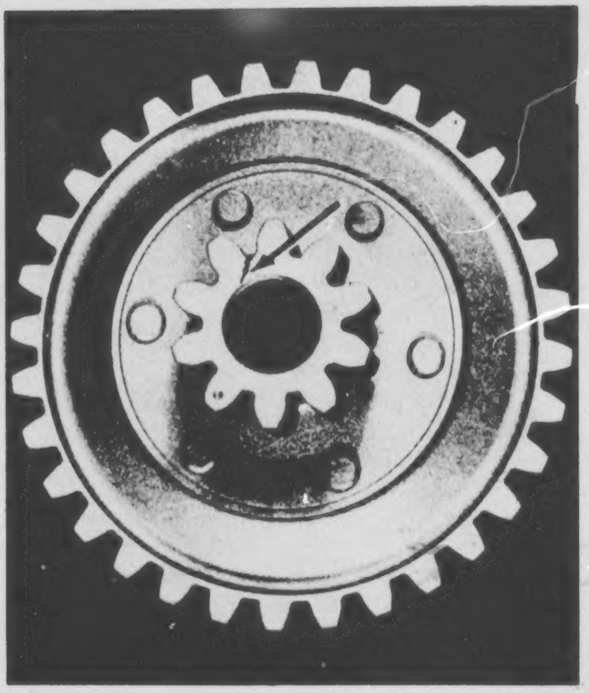
Fatigue Cracks

Fatigue cracks give sharp, clear patterns, generally uniform and unbroken throughout their length and with good buildup. They are often jagged in appearance as compared with the straight indications of a seam and may also change direction slightly in localized areas. Figure 5-9 illustrates a fatigue crack in a crankshaft. Figure 5-10 illustrates a fatigue crack in a gear.

Fatigue cracks are found in parts that have been in service, but are never found in new parts. They are usually in high-stressed areas of the part, or where a stress concentration exists for some reason. It is important to recognize that even a small fatigue crack indicates positively that failure of the involved part is in progress.

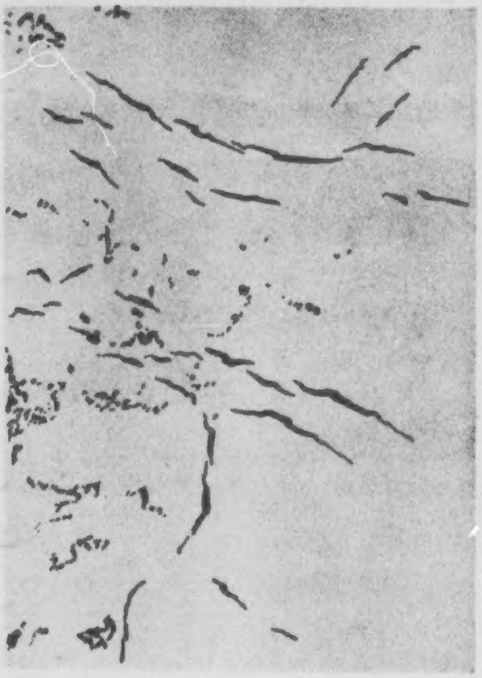
Heat-Treat Cracks

Heat-treat cracks have smooth outline, but are usually less clear and have less buildup than fatigue cracks. On thin sections, such as cylinder barrel walls, heat-treat cracks may give very



216.12

Figure 5-10.—Fatigue crack in a gear.



216.13

Figure 5-11.—Heat-treat cracks on cylinder barrel wall.

heavy patterns (fig. 5-11). These heat-treat cracks have a characteristic form, consisting of short jagged lines grouped together.

Shrink Cracks

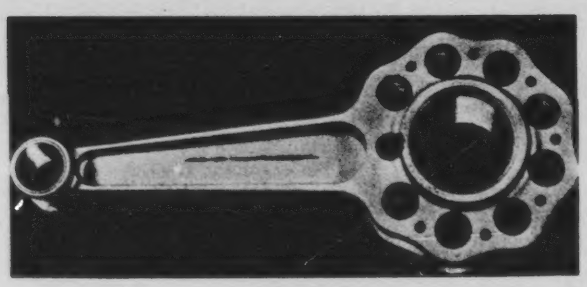
Shrink cracks give a sharp clear pattern, and the line is usually very jagged. Since the walls of shrink cracks are close together, their indications generally build up to less extent than do indications of fatigue cracks. (See fig. 5-12.)

Grinding Cracks

Grinding cracks are fine and sharp, but seldom have a buildup because of their limited depth. Grinding cracks vary from single line indications to a heavy network of lines. Grinding cracks are generally related to the direction of grinding. For example, the crack usually begins and continues at right angles to the motion of a grinding wheel, giving a rather symmetrical pattern. Indications of grinding cracks can frequently be identified by means of this relation.

216.14

Figure 5-12.—Shrink crack in welded joint.



216.15

Figure 5-13.—Seam in master rod.

Seams

Indications of seams are usually straight, sharp, and fine. They are often intermittent and sometimes have very little buildup. (See fig. 5-13.)

Hairlines

Hairlines are very fine seams in which the faces of the seam have been forced very close together during fabrication. Hairline indications are very fine and sharp, and have very little buildup. Discontinuities of this type are normally considered detrimental only in highly stressed parts.

Inclusions

Inclusions are nonmetallic materials, such as slag, unruly materials, and chemical compounds, that have been trapped in the solidifying ingot. They are usually elongated and strung out as the ingot is worked in subsequent processing operations.

Inclusions appear in parts in varying sizes and shapes, from stringers easily visible to the eye to particles only visible under magnification. In a finished part they may occur as either surface or subsurface discontinuities.

Indications of subsurface inclusions are usually broad and fuzzy. They are seldom continuous or of even width and density throughout their length. Larger inclusions, particularly those near or open to the surface, appear more clearly defined. Close examination, however, will generally reveal their lack of definition and the fact that the indication consists of several parallel lines rather than a single line. These characteristics will usually distinguish a heavy inclusion from a crack.

Pipes and Deep-Seated Cavities

When pipes or other cavities are located considerably below the surface of a part, the magnetic particle test is not a reliable method of detecting them. If any indication is obtained, it is likely to be an indistinct and inexact outline of the cavity, with the magnetic substance tending to distribute over the whole area rather than to outline clearly the boundary of the discontinuity. Defects of this type are better detected by radiographic procedures.

Laps

Laps may be identified by their form and location. They tend to occur at the points of maximum flow of metal; for example, at the ends or flash line of a forging. The indications are usually heavy and irregular. Islands and short branch indications usually break a lap indication of any length, and the scale included in the lap invariably gives fuzzy or small fern-like patterns stemming from the main indication.

Segregations

When an ingot solidifies, the distribution of the various elements or compounds generally is not uniform throughout the mass of the ingot. Marked segregations of some constituents may thus occur. As the ingot is forged and then rolled, these segregations are elongated and reduced in cross section. Upon subsequent processing, they may appear as very thin parallel lines or bands, known as banding.

Segregation in the form of banding is sometimes revealed by magnetic particle inspection, particularly when high field strengths are used. Banding is not normally considered significant.

The most serious forms of segregations probably occur in castings. Here, the basic condition of the metal remains unaltered in the finished part, and any segregations occur as they were originally formed. They may vary in size and will normally be irregular in shape. They may occur on or below the surface.

Incomplete Weld Penetration

Using magnetic particles, it is possible to find porosity, slag inclusions, shrink cracks, inadequate penetration, and incomplete fusion. Selective use of magnetizing currents is necessary so that both surface and subsurface discontinuities are revealed. Inadequate penetration is generally revealed as a broad and fuzzy pattern.

General Interpretation Considerations

Negative results, those showing no magnetic particles clinging to the surface areas of the materials being tested, indicate a freedom from defects insofar as the magnetic particle test can determine.

A positive result, showing accumulation of particles over one or more surface areas, requires interpretation that the indication reveals a defect or is nonrelevant. In making this determination, the inspector must consider the material of which the part is made, part processing methods, heat-treating operations, and finishing operations. The inspector familiar with these areas will be aware of the types of defects the various metals and processes can introduce and will know in advance what defects may be present.

Nonrelevant Indications

Some indications revealed by the magnetic particle inspection reveal design features or other insignificant characteristics such as variation in material, sharp edges, etc. Recognition of nonrelevant indications can be accomplished by the reinspection of the part using a lowered current setting, relating the indication to some feature of construction or cross section that accounts for a flux leakage, determining whether the part was overmagnetized during the inspection, etc. Some nonrelevant indications are identified in table 5-1. The ability to recognize indications of actual discontinuities, so as to identify them definitely, will depend on the inspector's experience level. Supplemental tests, including direct surface inspection, reinspection, inspection with magnifying viewing instruments, etc., will aid the inspector in verifying his results until he has gained adequate experience. The handbook on the magnetic particle method of inspection of material (NavAir 00-15PC-503) provides additional information on interpretation of indications and all other areas of the magnetic particle inspection procedures. NavAir 01-1A-16, *Technical Manual for Nondestructive Inspection Methods,* provides complete coverage on magnetic particle inspection and all other nondestructive inspection processes discussed in this chapter.

MAGNETIZING EQUIPMENT

STANDARD GENERAL-PURPOSE UNIT

A standard general-purpose unit used at many naval air activities is shown in figure 5-14. This unit provides direct current for wet continuous or residual magnetization procedures. Either circular or longitudinal magnetization may be used, and it may be powered with rectified alternating current as well as direct current.

The contact heads (1) and (2) provide the electrical terminals for circular magnetization. One head (1) is fixed in position. Its contact plate (3) is mounted on a shaft surrounded by a pressure spring (5), in order that the plate may be moved longitudinally. The plate is maintained in the extended position by the spring until pressure transmitted through the work from the movable head forces it back.

The movable head slides horizontally in longitudinal guides and is motor driven. It is controlled by a switch (7). The spring (5) allows sufficient overrun of the motordriven head to avoid jamming it, and also provides pressure on the ends of the work to ensure good electrical contact.

A plunger-operated switch in the fixed head cuts out the forward motion circuit of the movable head motor when the spring has been properly compressed.

Table 5-1.—Nonrelevant magnetic particle indications

Type of nonrelevancy	Indication characteristics
Structural.	Fairly wide, lacking character and clarity. Usually show relationship to abrupt structural changes in section such as keyways, drilled holes near the surface or bandings. Can mask significant indications, particularly if field strength is too high. (To eliminate nonrelevant indications where significant discontinuities are suspected, the field strength should be lowered or holes should be plugged with a ferromagnetic material.)
Material variation.	Confusing and unrelated to discontinuities. Caused by strong local poles or zero fields in the material under test, such as in cold worked areas.
Dissimilar metal contact.	Occur at points where defects are likely to be found. Cannot be eliminated by reduction of field strength. Difficult to distinguish from significant indications on dissimilar metals, especially when welded. (Several procedures are recommended for the inspection of such parts: magnetic particle test for ferromagnetic areas; possibly fluorescent penetrant test for nonmagnetic parts and junctions; and magnification, or possibly etching, for abrupt changes of section between two weld beads.)
Magnetic writing.	Usually vague and without character but can be sharp and clear and positioned to simulate actual discontinuities. Disappear on demagnetization and reinspection. (Parts should be kept from striking each other or other ferromagnetic materials to prevent local surface polarities and flux leakages from producing magnetic writing during inspection.)
Strains.	Reasonably sharp and distinct when caused by local cold working from blows and scratches. Specific patterns indicate obliterated stamp markings. Are produced by internal strains because of differences in the magnetic properties of strained and unstrained sections. Reappear after demagnetization and remagnetization. Infrequently encountered. Are sometimes confused with indications of surface defects and subsurface inclusions. (Differences can be discovered when some of the metal of the area is removed: indications decrease with nonrelevant local cold-working, remain unchanged or increase with subsurface discontinuity.)
Faulty operation.	Frequently resemble indications of discontinuities when trapped by grease or other foreign material left on part surface, but do not reappear after part is thoroughly cleaned and reinspected.

Table 5-1.–Nonrelevant magnetic particle indications–continued

Type of nonrelevancy	Indication characteristics
Faulty operation.	Accumulate at low points during draining of cylindrical parts with long axis horizontal, unless removed by rinsing. Caused by scale on surface of part. (Scale forced into the surface of the metal during forging may produce significant indications difficult to identify; removal of small portion of the metal permits positive or negative identification.)
Scratches.	May have characteristics similar to those of cracks, such as orientation transverse to grain flow; distinguished by lack of buildup.

In some units the movable head is hand-operated, and the contact plate is sometimes arranged for operation by an air ram. Both contact plates (3 and 4) are fitted with various fixtures for supporting the work.

The magnetizing circuit is closed by depressing a pushbutton (6) on the front of the unit. An automatic timer controls the duration of the shot or current flow. A shot of 3/4 to 1 1/4 seconds duration is recommended.

The strength of the magnetizing current may be set manually to the desired value by means of the rheostat (9), or increased to the capacity of the unit by the rheostat short-circuiting switch (15). The current utilized is indicated on the ammeter (8).

Longitudinal magnetization is produced by the coil (10), which moves in the same guide rail as the movable head and is connected in the electrical circuit by means of a switch (11).

The suspension is contained in a sump tank and is agitated and circulated by a pump (14). The suspension is applied to the work through a nozzle (12). The suspension drains from the work through the wood grill into a collecting pan that leads back to the sump. The circulating pump is operated by a pushbutton switch (13).

GENERAL-PURPOSE PORTABLE UNIT

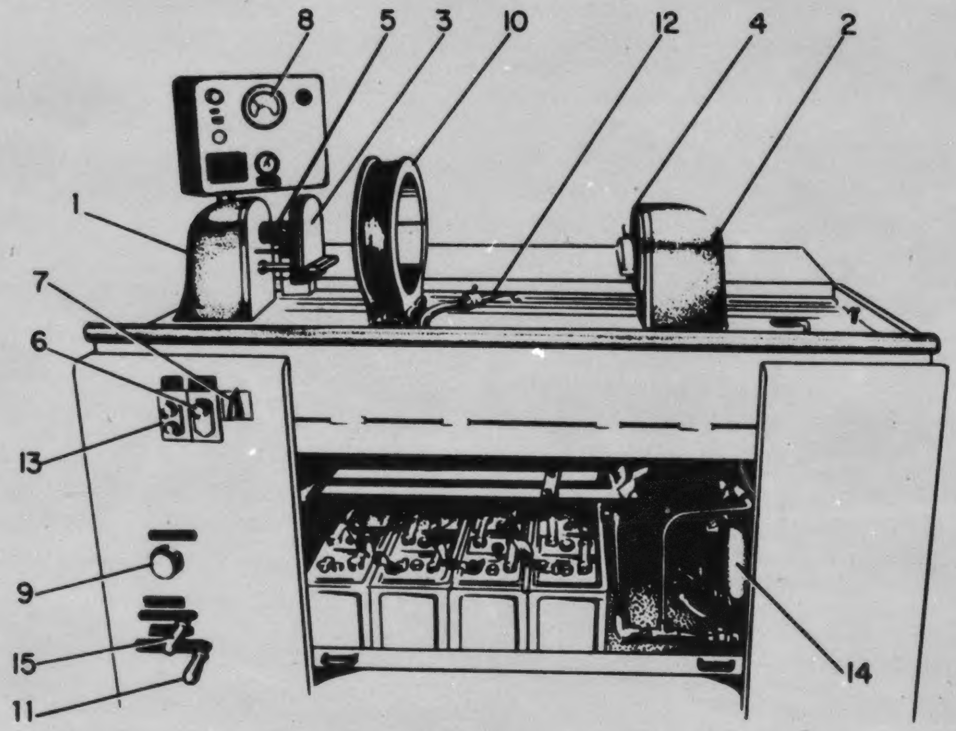
It is often necessary to perform the magnetic particle inspection at locations where standard general-purpose equipment is not available, or to perform an inspection on members of aircraft structures without removing them from the aircraft. This has occurred, particularly on landing gears and engine mounts suspected of having developed cracks in service. Equipment suitable for this purpose, supplying both alternating-current and direct-current magnetization, is available.

A typical example of a portable magnetic inspection unit and common accessories is provided in figure 5-15.

This unit is only a source of magnetizing and demagnetizing current and does not provide a means of supporting the work or applying the suspension. It operates on 220-440 volt, 50-60 hertz alternating current and contains a rectifier for producing direct current when required.

The magnetizing current is supplied through the two flexible cables. The cable terminals may be fitted with prods, as shown in the illustration, or with electrical clips. Circular magnetization may be developed by using either the prods or the clips. Longitudinal magnetization is developed by wrapping the cable around the part.

The strength of the magnetizing current is controlled by the 30-point rotary (tap) switch. This switch is used to manually select the amount of magnetizing current required for the job at hand. Output currents up to 3,000 amperes are available on either ac or dc with normal length output cables. The amount of current available on any tap or switch setting depends upon the resistance in the output circuit. In general, the lower the tap setting the



1. Contact head.
2. Contact head.
3. Contact plate.
4. Contact plate.
5. Pressure spring.
6. Pushbutton.
7. Switch.
8. Ammeter.
9. Rheostat.
10. Coil.
11. Switch.
12. Nozzle.
13. Pushbutton switch.
14. Pump.
15. Short-circuiting switch.

216.16

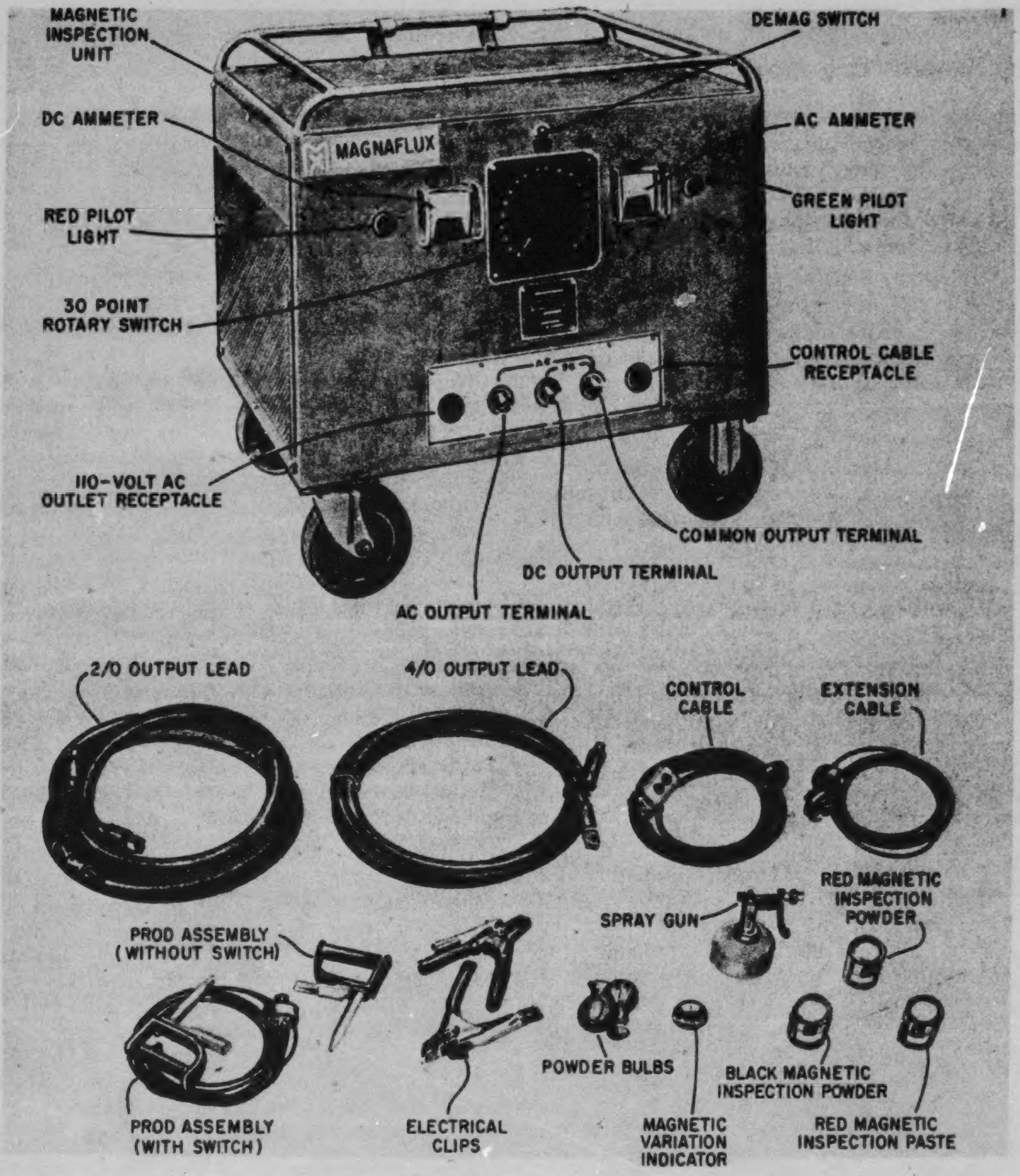
Figure 5-14.—Standard general-purpose magnetizing unit.

higher the ampere setting that is available with tap number 30 providing the lowest current. During automatic demagnetization, using the DEMAG switch, the rotary switch is motor-driven to reduce the output current in steps from any preset contact position to the minimum current obtainable on contact No. 30.

The control cable shown in figure 5-15, has two pushbuttons marked START and STOP. With line voltage available to the unit and the control cable connected to its receptacle, pressing the start button completes the circuit to the output terminals.

The DEMAG switch located on the front of the cabinet is depressed along with the START switch on the control cable to initiate the automatic demagnetizing cycle.

One prod assembly has a built-in control switch which connects through a cable to the


MAGNETIC INSPECTION UNIT
DEMAG SWITCH
DC AMMETER
AC AMMETER
MAGNAFLUX
RED PILOT LIGHT
GREEN PILOT LIGHT
30 POINT ROTARY SWITCH
CONTROL CABLE RECEPTACLE
110-VOLT AC OUTLET RECEPTACLE
COMMON OUTPUT TERMINAL
DC OUTPUT TERMINAL
AC OUTPUT TERMINAL
2/0 OUTPUT LEAD
4/0 OUTPUT LEAD
CONTROL CABLE
EXTENSION CABLE
RED MAGNETIC INSPECTION POWDER
SPRAY GUN
PROD ASSEMBLY (WITHOUT SWITCH)
POWDER BULBS
BLACK MAGNETIC INSPECTION POWDER
PROD ASSEMBLY (WITH SWITCH)
ELECTRICAL CLIPS
MAGNETIC VARIATION INDICATOR
RED MAGNETIC INSPECTION PASTE

216.18

Figure 5-15.—Portable magnetic inspection unit and accessories.

control cable receptacle. When prods are being used, this switch serves the same function as the start button on the control cable. When depressed, the switch directs power to the output terminals.

The red pilot light glows whenever line current is supplied to the unit. The input line switch is located on the right-hand end of the cabinet. The green pilot light is wired in the output circuit and will glow whenever the start button on the control cable or the prod control switch is depressed.

The dc ammeter indicates the output current when dc current is being used for magnetization. The ac ammeter indicates the output current when ac current is being used for magnetization or demagnetization.

The 110-volt ac receptacle is provided for convenience in plugging in lamps or other auxiliary equipment that may be required when performing inspections with the unit. Operating and servicing instructions for this unit are provided in detail in NavAir 17-15-16.

PARKER CONTOUR PROBE UNIT

The Parker Contour Probe, illustrated in figure 5-16, is a portable self-contained unit with flexible pole pieces that permit concentrated magnetic fields to be induced at the area to be inspected, regardless of part size or mass. Its solid state circuitry, contained within the aluminum handle, produces a constant ac magnetic field or a high-intensity pulsed dc field that is variable from zero to maximum intensity.

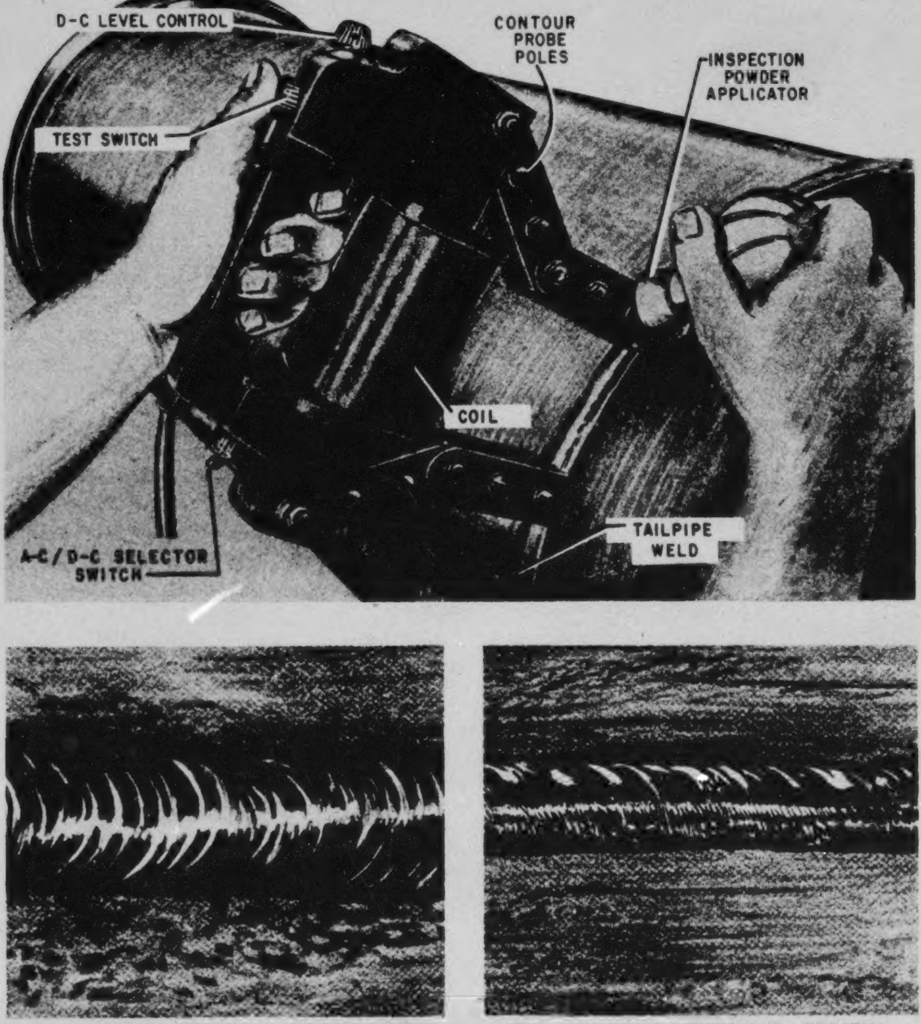
Basically, the contour probe is an improvisation of the C-shaped yoke with the addition of movable poles to permit the concentrated fields to be focused and applied at a precise area. The probe is capable of reproducing or duplicating any surface defect indication obtained by the use of large, high-amperage units discussed previously.

AC magnetization is induced in the part being inspected as a skin or surface field and does not penetrate the cross section of the material. It is used when only surface indications are required. It is most desirable for inspecting large masses and soft materials such as cast iron. With ac, the polarity reversal at the 60-hertz rate produces a profound surge peak that is reflected in the magnetic field produced by the coil. Byproducts of ac magnetization are the formation of eddy currents that tend to guide or direct the magnetic field in a narrow pattern between the poles and a vibratory action at the workpiece that adds mobility to the inspection particles to form a large and sharper buildup at the defect. AC is used for the demagnetization process.

Pulsed dc magnetization penetrates the entire cross section of the workpiece and tends to spread out on each side of the line between the poles, thus dispersing the field energy over a greater area. To offset the dissipation of the energy, the magnetic field strength in the maximum dc position is almost double that of the ac mode. The dc mode can be used in the residual method of inspection of small parts. When using ac or dc on small parts, an excess amount of field will completely saturate the part and cause a masking effect that blurs or obliterates defect indications. Always use the lowest current setting that will produce sharp and distinct indications with maximum sensitivity.

The probe pole pieces are adjustable to a variety of configurations. They can be extended to a maximum of 18 inches; however, it is recommended that when possible they be used with a space of approximately 5 to 6 inches inside diameter. The closer spacing provides a higher density field over a small area.

Operation of the contour probe is simple. With the probe set in either the ac or the maximum dc position, place the pole pieces on the work with the suspected defect at right angles to the poles. Push the test switch and dust or float the inspection powder over the area being inspected. Release the test switch immediately after application of the inspection powder. Read defect indications revealed by the accumulation of inspection powder over defects. Turn the probe 90 degrees and repeat the procedure so that defects oriented opposite to the first indication may be revealed. Figure 5-16 illustrates the contour probe being used to inspect a jet engine tailpipe weld and the resulting indications.


D-C LEVEL CONTROL
CONTOUR PROBE POLES
INSPECTION POWDER APPLICATOR
TEST SWITCH
COIL
TAILPIPE WELD
A-C/D-C SELECTOR SWITCH

WELD SURFACE DISCONTINUITY INDICATION

WELD SUBSURFACE DISCONTINUITY INDICATION

216.19

Figure 5-16.—Parker Contour Probe being used to inspect tailpipe welds.

The probe should be operated on 105-125 volts ac, 60-hertz, single-phase power. The duty cycle for the test switch should not exceed 2 minutes ON, 2 minutes OFF. Heating of the coil cover indicates excessive ON time. The selector switch for ac/dc should not be changed with the test switch depressed.

ACCESSORIES AND FIXTURES

Clamps and Prods

In testing large items with flat surfaces such as engine section rings, it is desirable to use clamping devices to facilitate application of the

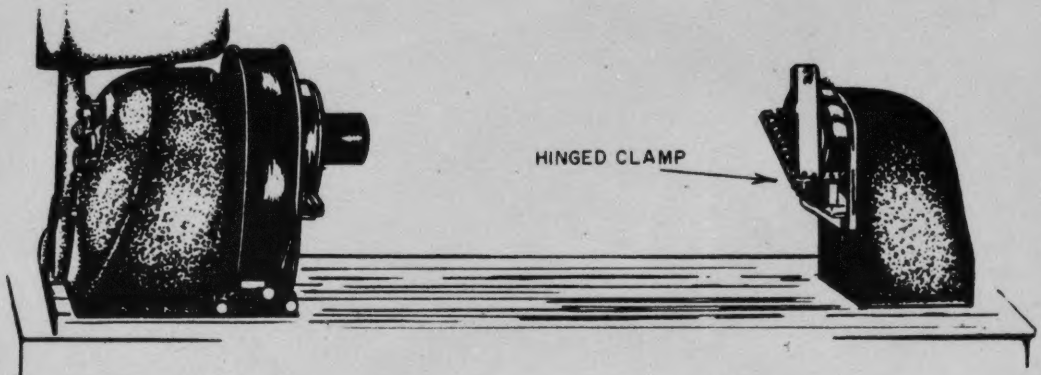


Figure 5-17.—Propeller blade fixture.

magnetizing current. On parts where it is impractical to use clamps, prods similar to those illustrated in figure 5-6 are used.

Prods may be used with the standard general-purpose unit and the portable unit. The part or assembly being tested may be suspended above the standard unit and the wet suspension indicating medium hosed onto the area with the excess suspension draining into the tank. The dry indicating medium may also be used.

In using the prods, they should be held firmly against the surface being tested. This will prevent or minimize the tendency for burning at the contact points. For applications where prod magnetization is acceptable, slight burning is normally not objectionable.

Contact Blocks

When it is desired to use cable with the standard general-purpose unit as a source of power, a contact block is useful. This consists of a wooden block fitted at each end with copper plates spaced to receive the terminals of the cable.

When the contact block is placed between the heads of a standard unit, the regular controls and timing switches of the unit can be used to regulate the magnetizing current. This provides a convenient way of connecting the cable to a power source and eliminates the necessity for bolted connections. Recommended magnetizing currents, for specific applications including the recommended current path and ampere value, are given in NavAir 00-15PC-503 and NavAir 01-1A-16.

Propeller Blade Fixtures

When magnetizing current is passed through a propeller blade for circular magnetization, it is possible to burn the blade tip. This possibility can be avoided by the use of a hinged clamp attached to the movable head of the inspection unit, as shown in figure 5-17.

The clamp is lined with copper braid, which provides a good electrical contact by conforming to the curvature of the propeller blade faces. This fixture arrangement eliminates high current intensities at the thin edge of the blade tip, which may cause burning at the point. The butt end of the blade is supported by a plug mounted on the opposite head.

MAGNETIZING MATERIALS

LIQUID VEHICLE FOR WET SUSPENSION

The liquid vehicle in the wet procedure performs the basic function of providing mobility for the suspended magnetic particles.

The liquid for the oil-suspended method should be a light oil such as kerosene or drycleaning solvent. Water with a suitable inhibitor and wetting agent may be used as a liquid vehicle. Most magnetic materials for suspension in water are supplied with water conditioners which have some rust-inhibiting characteristics and also increase the wetting action of the bath. The type and amount of water conditioner used should be in accordance with the manufacturer's recommendations. Too much conditioner in the mixture will result in excess foaming of the bath.

INDICATING MEDIUMS

The various types of indicating mediums available for magnetic particle inspection may be divided into two general types–wet process and dry process materials. The basic requirement for any indicating medium is that it produce acceptable indications of discontinuities in parts.

The contrast provided by a particular indicating medium on the background or part surface is particularly important. The colors most extensively used are black and red for the wet procedure; and black, red, and gray for the dry procedure.

For acceptable operation, the indicating medium must be of high permeability and low retentivity. High permeability ensures that a minimum of magnetic energy will be required to attract the material to flux leakage caused by discontinuities. Low retentivity ensures that the mobility of the magnetic particles will not be hindered; that is, by the particles themselves becoming magnetized and attracting one another.

The magnetic substance for the wet process is usually supplied in paste form. This paste is red in color and aids in improved visibility on dark surfaces. Fluorescent paste particles are also available and must be viewed under a black light. The primary advantage of fluorescent paste is the greatly increased visibility over regular paste when viewed under normal light.

When the suspension vehicle becomes discolored or contaminated to the extent that the formation of magnetic particle patterns is interfered with, the unit should be drained, cleaned, and refilled with clean suspension. When new suspension is prepared, it is important that the correct amount of paste is used. Oil-based baths should be completely replaced at least every two months. Water-suspended baths should be replaced at least every 30 days.

Mixing the Bath (Oil-Suspended Wet Method)

The proper procedure in preparing a suspension is to weigh or measure the paste into a clean container. When using black or red paste, measure out 1 1/2 ounces per gallon of oil. If the fluorescent paste is used, measure out 1/4 ounce per gallon of oil. If a dry concentrate is used, measure 1/5 ounce per gallon of oil. The dry particles may be poured directly into the tank, preferably over the sump for proper dispersing. The paste-type particles, being placed in a container, are diluted with small quantities of the liquid vehicle and mixed until they become a uniform watery mixture that can be poured into the tank. With the pump motor on, the mixture is poured over the sump area and the motor is allowed to operate several minutes. The bath strength is checked by using a centrifuge tube filled with properly agitated bath mixture. The centrifuge is allowed to set approximately 30 minutes, and the amount of particles settling to the bottom indicates the bath strength. For black or red paste, the reading should be from 1.7 to 2.4 cc; for fluorescent paste, from 0.1 to 0.5 cc; and for dry concentrate, 0.35 to 0.40 cc.

The wetting ability of water-based baths should also be checked at this time. If the bath does not thoroughly cover the test material, an additional amount of water conditioner should be added.

Mixing the Bath (Water-Suspended Wet Method)

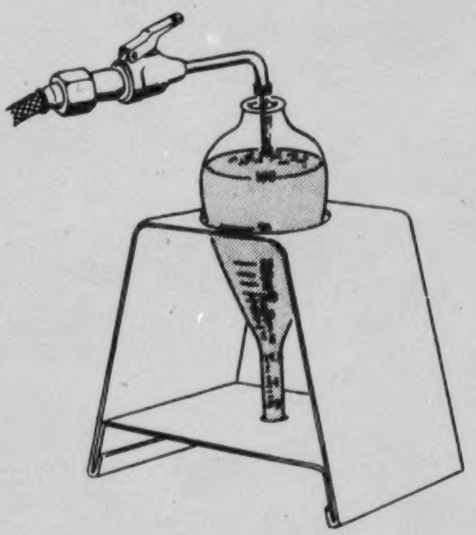
Magnetic particle baths using water as a vehicle require close control. They are recommended for use in activities performing magnetic particle inspections on a full-time basis. The particles may come in a paste or as a powder. They should always be used in accordance with the manufacturers' recommended procedures. When using red or black paste, measure out 2.4 to 4.4 ounces per gallon of water. If the fluorescent paste is used, measure out 0.16 to 0.20 ounces per gallon. Add a little water from the tank to the paste in the container and mix until a uniform, thin mixture is obtained. Pour into the tank over the sump area for proper dispersing throughout the tank. Powdered form fluorescent particles may be added to the water suspension material by weighing out the proper amount of powder, following the manufacturers' recommendations, and pouring the powder directly into the tank over the sump area. In every case of adding material to the tank, the pump motor should be operated several minutes to thoroughly agitate the mixture.

Bath Strength

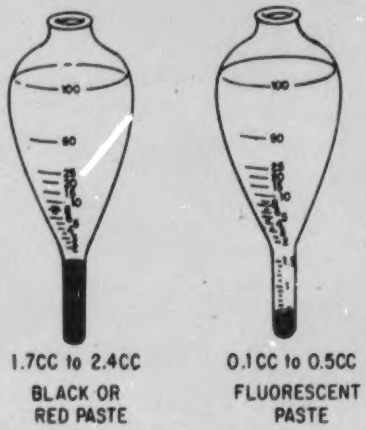
The bath strength of oil-suspended baths should be checked each day. The bath strength and wetting ability of water-suspended baths should be checked prior to each use and after each 4 hours of operation.

A centrifuge tube (view A, fig. 5-18) filled with a properly agitated bath mixture should be used to check bath strength. The bath mixture should be allowed to sit approximately 30 minutes. The amount of particles settling to the bottom indicates the strength. For black or red paste, the reading should be from 1.70 to 2.40 cc; for fluorescent paste, from 0.10 to 0.50 cc; and for dry concentrate, 0.35 to 0.40 cc, (view B, fig. 5-18).

After completion of the bath strength test, the wetting ability of the water-based baths should be checked. The bath should be flowed over a test part having a finely ground flat surface. The bath must thoroughly and completely cover the ground surface; if it tends to run back from the edges, an additional amount of water conditioner should be added until complete wetting of the surface is obtained. Water conditioner should be added in small quantities and retested after each addition—too much conditioner causes excess foaming of the bath.



FILLING CENTRIFUGE TUBE
(A)



INDICATION OF PROPER AMOUNT OF SETTLED PARTICLES
(B)

218.59

Figure 5-18.—Checking bath strength using a centrifuge tube.

Application of Indicating Mediums

The wet-type materials, after being properly agitated, may be poured or hosed onto the surface.

The dry-type particles should be floated to the surface and not forcibly thrown against it. Do not pour the particles on or roll the magnetized part in particles, as the particles will not be as free as necessary to be attracted to the leakage field and poor indications will result. Normally, field units use small rubber spray bulbs or shakers. These devices allow for gentle application of the indicating particles.

DEMAGNETIZATION

NECESSITY FOR DEMAGNETIZATION

In aircraft parts, the permanent magnetism remaining after inspection must be removed by a demagnetization operation if the part is to be returned to service. Parts of operating mechanisms must be demagnetized to prevent magnetized parts from attracting filings, grindings or chips inadvertently left in the system, or steel particles resulting from operational wear.

An accumulation of such particles on a magnetized part may cause scoring of bearings or other working parts. Parts of the airframe must be demagnetized so that they will not affect instruments.

Demagnetization of a part is not required if the part is to be heat-treated and brought up to a temperature of 1700°F or higher, or will be remagnetized during further handling, or will be magnetized later in another direction to the same or higher level than originally magnetized.

In order to ensure acceptable magnetization, it has been found desirable in some instances to magnetize a part twice in succession in the final direction prior to its inspection.

BASIC THEORY

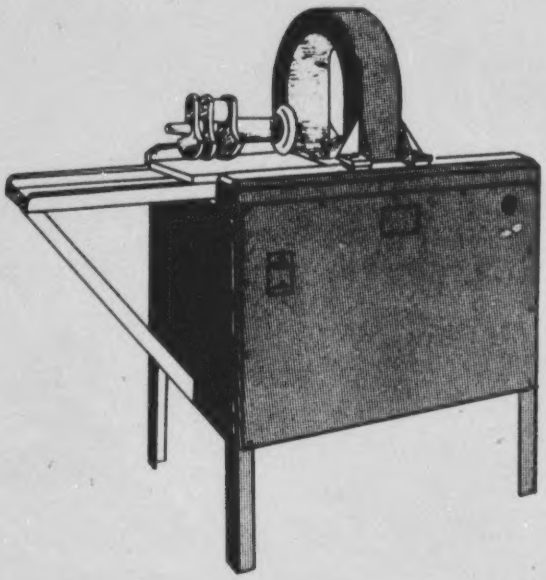
Demagnetization may be accomplished in a number of different ways. Possibly the most convenient procedure for aircraft parts involves subjecting the part to a magnetizing force that is continually reversing in direction and, at the same time, gradually decreasing in strength. As the decreasing magnetizing force is applied first in one direction and then the other, the magnetization of the part also decreases.

STANDARD DEMAGNETIZING PRACTICE

The simplest procedure for developing a reversing and gradually decreasing magnetizing force in a part involves the use of a solenoid energized by alternating current. As the part is moved away from the alternating field of the solenoid, the magnetism in the part gradually decreases.

This principle is utilized in the demagnetizer shown in figure 5-19. In demagnetizers of this type, the strength of the demagnetizing field decreases toward the center of the coil. A demagnetizer as near the size of the work as practicable should be used; and for maximum effectiveness, small parts should also be held as close to the inner wall of the coil as possible.

Parts that do not readily lose their magnetism should be passed slowly in and out of



216.21

Figure 5-19.—Narrow coil demagnetizer.

the demagnetizer several times, and at the same time tumbled or rotated in various directions. Allowing a part to remain in the demagnetizer with the current on accomplishes very little practical demagnetization.

The effective operation in the demagnetizing procedure is that of slowly moving the part out of the coil and away from the magnetizing field strength. As the part is withdrawn, it should be kept directly opposite the opening until it is 1 or 2 feet from the demagnetizer.

The demagnetizing current should never be cut off until the part is 4 or 5 feet from the opening, as this will usually result in remagnetization of the part.

DEMAGNETIZING EQUIPMENT

NARROW COIL SOLENOID

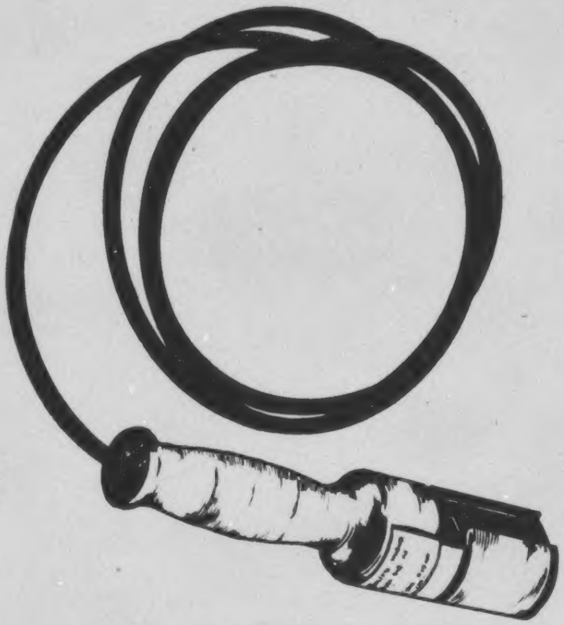
The most widely used type of demagnetizer consists of a solenoid excited by alternating current. An example of this type demagnetizer is shown in figure 5-19. The windings consist of flat copper strip compactly wound to shorten the length of the demagnetizer. These demagnetizers are normally supplied in different size openings to efficiently handle various sized parts. A sliding carrier may be incorporated for convenience in demagnetizing heavy parts.

The narrow coil demagnetizer heats quickly and is not designed for very long periods of continuous operation. The manufacturer's instructions should always be consulted for the intermittent operation of these units.

PORTABLE ELECTROMAGNET-TYPE DEMAGNETIZER

A portable electromagnet-type demagnetizer is shown in figure 5-20. It consists of a flat slab electromagnet, wound in the long direction. The faces of the exposed pole ends are rounded to permit access into localized areas, such as holes or corners.

The demagnetizer produces an external alternating field when excited by alternating current. When it is slowly moved away from the part, it demagnetizes the adjacent area in the usual manner.



216.22

Figure 5-20.—Hand-type demagnetizer.

This tool is convenient for use on localized areas difficult to demagnetize by the standard procedure. It requires a power source of about 3 amperes and 100 volts at 60 hertz, and may thus be plugged into most lighting circuits.

PARKER CONTOUR PROBE DEMAGNETIZATION FEATURE

Demagnetization with the Parker Contour Probe is accomplished using alternating current. Small pieces which have been residually magnetized by either the ac or the dc method are passed through the area between the poles and withdrawn to a distance of 2 feet before the test switch is released. On larger pieces, place the probe in the same position used for magnetizing the part, turn on the probe and lift from the work to a distance of 2 feet before releasing the test switch.

INSPECTION RECORDS AND REPORTS

The results of magnetic particle inspections can be recorded for future reference by a variety of methods. If the part is being retained for further viewing or being shipped to a higher level maintenance activity, it may be desirable to fix the indication in place on the part. This may be accomplished using a lacquer overspray or applying transparent tape over the indications. Other methods include simple sketches, photographs, and tape transfer of indications onto stiff white paper.

Reports of unsatisfactory or defective materials revealed by magnetic particle inspection should be made on the Unsatisfactory Material/Condition Report (UR), OPNAV Form 4790/47. Such reports should contain a complete identification of the part, a visual record of the results with a supplemental written description, a complete evaluation of the indications, and the procedure used to magnetize the part and apply the indicating medium, including the current strength for circular magnetization or the ampere turns for longitudinal magnetization.

CHAPTER 6

POWER SYSTEM MAINTENANCE

HYDRAULIC POWER SYSTEMS

SYSTEM DESIGN

Hydraulic systems and components to be utilized on naval aircraft are designed to operate satisfactorily under all conditions that the aircraft might encounter, within the structural limitations of the aircraft. These conditions include forces or conditions caused by acceleration, deceleration, zero gravity (G's), negative G, or any flight attitudes obtainable with the aircraft, structural deflection, vibration, or other environmental conditions.

Flight control system design specifications require two separate systems for operating the primary flight controls. All aircraft which utilize hydraulically actuated flight controls have at least two hydraulic power systems, one of which supplies pressure to the utility or normal system in addition to the flight controls. The flight/utility system, when combined, is designed so that the flight system portion can be given pressure priority by means of an isolation valve. This isolates nonessential flight functions and prevents unnecessary loss of hydraulic fluid in the event of rupture in any portion of the utility system during flight.

As a minimum requirement, filters must be provided in each system pressure line, return line, and pump bypass or case drain line. Where hydraulic sequencing is critical, each sequence valve is protected from contamination in each direction of flow by a screen type filter that is usually included as a part of the sequence valve. The pressure line filter(s) will be located so that all fluid from the aircraft pump(s) or the ground test equipment will be filtered prior to entering any major equipment or components of the system. The return line filter(s) will be located so that all fluid entering the return circuit is circulated through a filter prior to entering the return line relief valve, pump(s), or reservoir.

In some larger aircraft hydraulic systems, the fluid demand by some of the actuating mechanisms is often greater than the output capacity of a single pump. Dual pumps may be used; and if the aircraft is a multiengine aircraft, the pumps are normally driven by separate engines. This provides a greater fluid supply and ensures hydraulic system operation in the event of an engine failure or the failure of one of the pumps. Both pumps supply the same system by combining their volume into a common pressure manifold.

Most aircraft manufacturers refer to the system supplying pressure only for the control surfaces as power control system 1 (PC-1). If there are only two hydraulic systems, the system supplying the other half of the flight control tandem actuating mechanisms and utility hydraulic systems is referred to as power control system 2 (PC-2). The PC-2 system may also be referred to as the combined hydraulic system. If there are three hydraulic power systems, they are generally identified as PC-1, PC-2, and utility system. The utility system is labeled as PC-3 by some manufacturers. Each system has its own reservoir, power pump(s), and plumbing.

Complete design, installation, and data requirements for aircraft hydraulic systems are provided in *Military Specifications* MIL-H-5440 (Series). This specification provides reference to all other specifications concerning aircraft hydraulic systems, such as hose assemblies, hose support requirements, protection, minimum bend radii, types of pumps, types and classes of systems, etc.

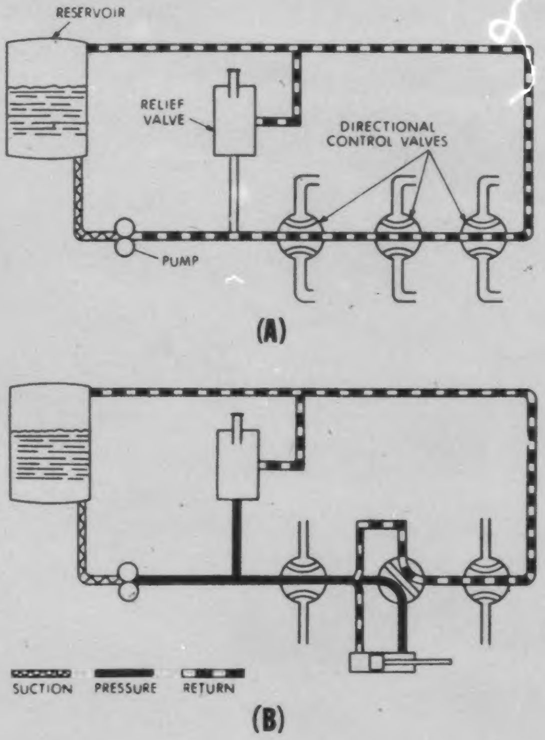
Many Maintenance Instructions Manuals refer to aircraft hydraulic systems as being open center or closed center systems. A discussion of these systems is provided in the following paragraphs.

Open Center

An open center system is one having fluid flow, but no pressure in the system when the actuating mechanisms are idle. The pump circulates the fluid from the reservoir, through the selector valves, and back to the reservoir. Figure 6-1 illustrates a basic open center system. The open center system may employ any number of subsystems with a selector valve for each subsystem. Unlike the closed center system, the selector valves of the open center system are always connected in series with each other, an arrangement whereby the system pressure line goes through each selector valve. Fluid is always allowed free passage through each selector valve and back to the reservoir until one of the selector valves is positioned to operate a mechanism.

When one of the selector valves is positioned to operate an actuating device, as shown in view (B) of figure 6-1, fluid is directed from the pump through one of the working lines to the actuator. With the selector valve in this position, the flow of fluid through the valve to the reservoir is blocked. Thus, the pressure builds up in the system to overcome the resistance and move the piston of the actuating cylinder. The fluid from the opposite end of the actuator returns to the selector valve and flows back to the reservoir. Operation of the system following actuation of the component depends on the type of selector valve being used.

Several types of selector valves are used in conjunction with the open center system. One type is the manually engaged and manually disengaged. After this type valve is manually moved to an operating position and the actuating mechanism reaches the end of its operating cycle, pump output continues until the system relief valve setting is reached. The relief valve then unseats and allows the fluid to flow back to the reservoir. The system pressure remains at the pressure setting of the relief valve until the selector valve is manually returned to the neutral position. This action reopens the open center flow and allows the system pressure to drop to line resistance pressure.



194.38

Figure 6-1.—Basic open center hydraulic system.

The manually engaged and pressure disengaged type selector valve is similar to the valve previously discussed; however, when the actuating mechanism reaches the end of its cycle and the pressure continues to rise to a predetermined pressure, the valve automatically returns to the netrual position and, consequently, to open center flow.

Closed Center

In the closed center system, the fluid is stowed under pressure whenever the power pump is operating. The power pump may be one used with a separate pressure regulator control or one with an integral pressure control valve which eliminates the need for a pressure regulator. This system differs from the open center system in that the selector or directional control valves are arranged in parallel and not in series. The means of controlling pump pressure will vary in the closed center system. For example, if a constant delivery pump is used, the system pressure will be regulated by a pressure regulator and have a relief valve as a backup safety device in case the regulator fails. If a variable displacement pump is used, system pressure is controlled by the pump's integral pressure controlling mechanism. This mechanism automatically varies the volume output. When pressure approaches normal system pressure, flow cutoff begins and the pump reaches a zero flow or unloaded condition when normal system pressure is attained. When the pump is in this unloaded condition, the pump bypass mechanism provides circulation of some fluid through the pump internally for purposes of cooling and lubrication. A relief valve is installed in the system as a safety backup.

An advantage of the open center system over the closed center system is that the continuous pressurization of the system is eliminated. Since the pressure is gradually built up after the selector valve is moved to an operating position, there is very little shock from pressure surges. This provides a smooth operation of the actuating mechanisms; however, the operation is slower than the closed center system in which the pressure is available the moment the selector valve is positioned. Since most aircraft applications require instantaneous operation, closed center systems are the most widely used.

Power systems are designed to produce and maintain a given pressure. The pressure output of most of the Navy's high performance aircraft is 3,000 psi. However, some aircraft hydraulic systems operate at only 1,500 psi. A representative example of both types of systems is provided in the following section.

THE 1,500-PSI SYSTEM

The E-1B power system (fig. 6-2) is a representative example of a 1,500-psi power system. Since this aircraft does not have hydraulically actuated flight controls, it has only one power system.

This power system supplies 1,500-psi hydraulic pressure to the wing flap, landing gear, arresting hook, windshield wiper, wheel brakes, rudder boost, and wing fold systems. Pressure is supplied by two variable volume, closed center, engine driven pumps. One pump is mounted on the accessory section of each engine. A main reservoir (nonpressurized type) and an emergency reservoir, which are vented through a common line to the atmosphere, supply the necessary fluid for system operation,

With the engines operating, hydraulic fluid is drawn through suction lines from the main reservoir to the engine driven pumps, which then deliver hydraulic pressure to the system selector valves. A pressure relief valve is installed between the power system pressure lines and the return line to protect the system from excessive pressures caused by fluid surges, thermal expansion, or failure of the pump pressure control unit.

Each engine driven pump pressure line is equipped with a filter and a check valve (fig. 6-2) before the lines are combined into a single line. With this arrangement, if one engine driven pump is inoperative, the other engine driven pump will supply the system. The check valve in the inactive pump's pressure line will prevent fluid from passing to that pump and to the reservoir (or overboard in the case of a cracked pump), thus maintaining system pressure.

Electrically operated autosyn transmitters installed in each engine pressure line react to the discharge pressure of their respective pump by transmitting this information to gages located in the cockpit. A pressure snubber is located between each transmitter and its pump. These snubbers function to dampen surges in pressure, thereby protecting the transmitter against damage.

A ground test inlet and outlet are installed in the power system to facilitate ground testing. The inlet test connection is connected to the pump pressure line, and the outlet is connected to the suction line.

THE 3,000-PSI POWER SYSTEM

The hydraulic system of the A-6A is an example of a representative 3,000-psi hydraulic power system. The aircraft has three independent hydraulic power systems. The two primary systems are the flight hydraulic power system and the combined hydraulic power system. These systems are pressurized by two independent engine driven hydraulic pumps on each engine. The third system, the auxiliary power system, also operates on 3,000-psi pressure and is pressurized by the hydraulic hand pump and/or the electric motor driven hydraulic pump. Figure 6-3 illustrates the flight hydraulic power system schematic. The combined power section is similar in design except that it additionally supplies hydraulic pressure to utility hydraulic circuits as well as the flight controls.

The hydraulic control valves and actuators that operate the primary flight controls are of the tandem construction type, permitting operation from either or both of the two primary power systems. With this arrangement, either engine can fail or be shut down without complete loss of hydraulic power to either system. The flight system reservoir supplies fluid to the two engine driven flight system pumps. The combined system reservoir supplied fluid to the two engine driven combined system pumps and to the auxiliary hydraulic power system. Both reservoirs are of the pressurized piston type. They are pressurized by engine bleed air during engine operations and by an external air (nitrogen) source during maintenance operations.

Hydraulic system pressure is indicated on the integrated hydraulic pressure indicator. The indicator displays the output pressure of each engine driven pump of the flight and combined hydraulic power systems.

The flight hydraulic power system provides power for the operation of the rudder, stabilizer, and flaperons. It also provides power for operation of the automatic flight control system actuators, which are an integral part of the rudder and stabilizer control surface actuators. The flight hydraulic system also controls the automatic operation of the isolation valve, which is a part of the combined hydraulic system.

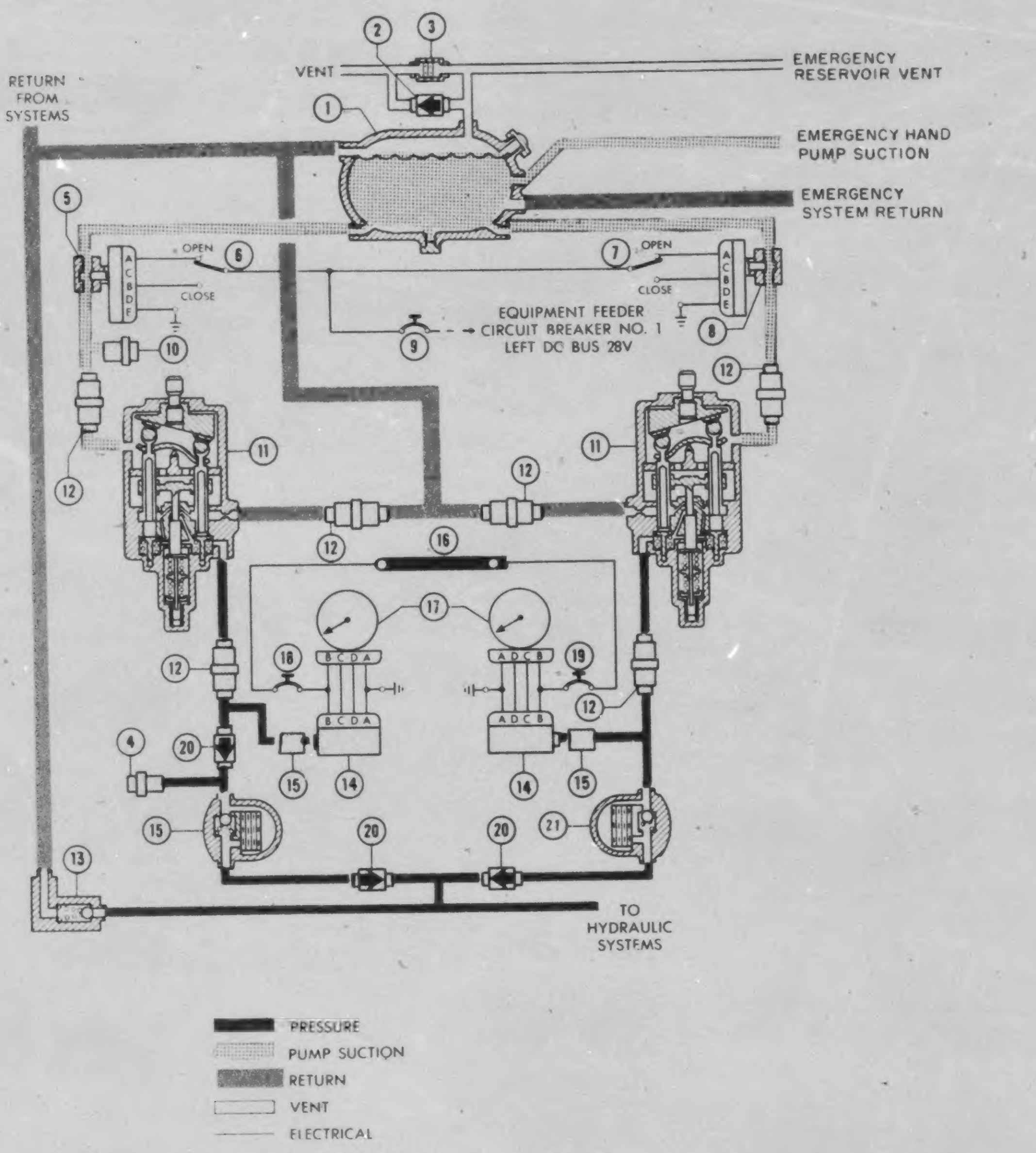
The combined hydraulic power system consists of two parallel circuits–one to power the primary systems, and the other to power the secondary systems. The primary system consists of spin recovery, rudder, stabilizer, flaperon, speed brakes, and electric ram-air-turbine systems. The secondary system consists of wing slats, wing flaps, flaperon pop-up, wing fold, canopy, landing gear, arresting gear, wheel brakes, nosewheel steering, and the nose strut locking systems.

The isolation valve shuts off flow to the secondary systems during flight and limits the combined system's pressure requirements to operation of the primary circuit. Operation of the isolation valve is both automatic and manual. The purpose and the operation of this valve are discussed later in this chapter.

The reservoir pressurization system provides the reservoir with a differential pressure of 40 psi to prevent engine driven pump cavitation. The pressure is maintained at 40 psi by the air regulator. In the event of regulator failure, the relief valve installed between the regulator and the reservoir prevents overpressurization. The relief valve opens at 50 psi. The chemical air drier removes excessive moisture from the bleed air, thus supplying dry clean air to the reservoir through the check valve, air regulator, and relief valve.

Two bleeder valves, one on the air side of the reservoir and one on the fluid side, are installed in the flight and combined system reservoirs. The air side valve permits the bleeding of air pressure during system maintenance and the bleeding of any hydraulic fluid seepage past seals to the air side. The fluid side bleeder is used to reduce excessive fluid level and to bleed air from the fluid side.

Quick-disconnect fittings used in the hydraulic power systems permit easy pump or


2
3
VENT
EMERGENCY
RESERVOIR VENT
RETURN
FROM
SYSTEMS
1
EMERGENCY HAND
PUMP SUCTION
EMERGENCY
SYSTEM RETURN
5
OPEN
6
A
C
B
D
E
F
CLOSE
7
OPEN
CLOSE
A
C
B
D
E
EQUIPMENT FEEDER
CIRCUIT BREAKER NO. 1
LEFT DC BUS 28V
9
8
10
12
11
12
11
12
12
12
16
17
12
18
B C D A
A D C B
19
12
B C D A
A D C B
4
20
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14
14
15
15
20
20
21
13
TO
HYDRAULIC
SYSTEMS
PRESSURE
PUMP SUCTION
RETURN
VENT
ELECTRICAL

216.34

Figure 6-2.—Representive 1,500-psi power system.

Nomenclature for figure 6-2

1. Main reservoir.
2. Vent check valve.
3. Vent filter.
4. Ground test inlet.
5. Left emergency hydraulic shutoff valve.
6. Left emergency hydraulic shutoff valve switch.
7. Right emergency hydraulic shutoff valve switch.
8. Right emergency hydraulic shutoff valve.
9. Emergency hydraulic shutoff valve circuit breaker.
10. Ground test outlet.
11. Engine driven hydraulic pump (2).
12. Quick disconnect (6).
13. Main relief valve.
14. Autosyn transmitter (2).
15. Pressure snubber.
16. A-c instrument bus.
17. Hydraulic pressure indicator.
18. Left hydraulic pump pressure gage circuit breaker
19. Right hydraulic pump pressure gage circuit breaker.
20. Check valve (4).
21. Filter (2).

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Figure 6-2.—Representive 1,500-psi power system—Continued.

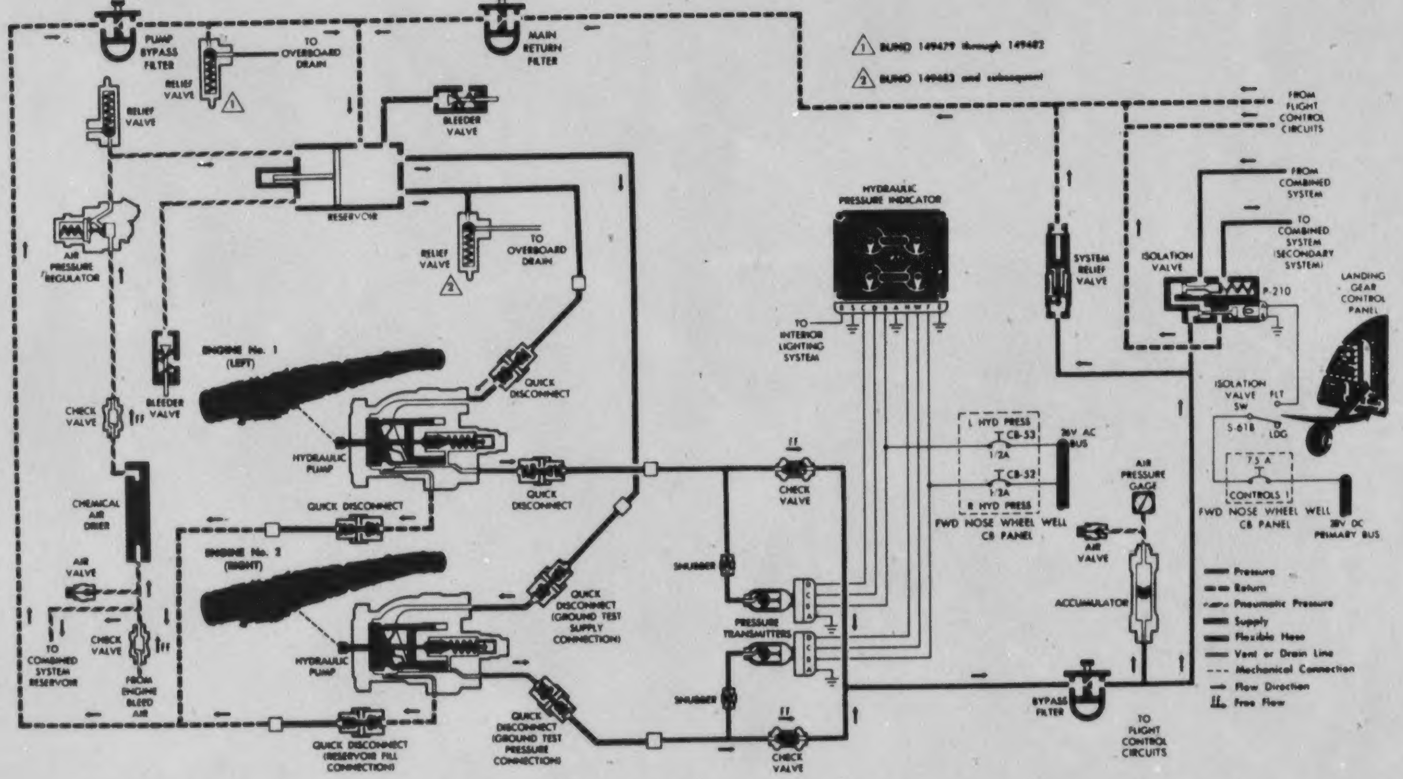
engine removal without loss of fluid to the system and are utilized to connect the ground hydraulic test stand for maintenance. The disconnect fitting separates into a bulkhead mounting half and a hose attaching half. Coupling is accomplished by aligning the halves and turning the union nut clockwise by hand until the female hex on the union nut sleeve is fully engaged with the male hex on the body. Uncoupling is accomplished by lifting up on the union nut and turning counterclockwise. In coupling, the poppet valve in the bulkhead half strikes the tubular valve in the hose half and begins to open, compressing its spring. When coupling is half completed, the valve sleeve in the hose half strikes the retainer in the bulkhead half and begins to open, compressing its spring. When completely coupled, both the poppet valve and the valve sleeve are fully retracted and the quick-disconnect fitting is open to full flow. In the uncoupling procedure, the valves reseat in the reverse order and the two halves are sealed against fluid leakage and/or introduction of air into the system. The pump disconnects should not be forced together against the back pressure of a pressurized reservoir or system.

This may result in damaged seals in the male ends of the disconnects. Whenever the disconnects do not slide in smoothly, they should be removed and checked for proper seating of the O-rings. If seals are damaged and have to be replaced, the teflon seal goes on top of the O-ring. When the disconnects are disconnected, the ends not being utilized should be properly protected from dirt and other contamination by covering them with small plastic lint-free bags.

SYSTEM MAINTENANCE

Hydraulic power system maintenance includes servicing, removing, and installation of components, troubleshooting/trouble analysis, and operationally testing for isolation and correction of malfunctions within the system. Scheduled maintenance generally encompasses the periodic changing of filters, the testing of emergency systems, operational ground checks, testing for contamination, and removal and replacement of high-time components. Some of these areas are covered in chapter 11 under General Hydraulic System Maintenance.

The applicable Maintenance Instructions Manual and/or 03 Manuals contain the informatin necessary for maintaining a power system. The MIM furnishes such information as proper procedures for all levels of maintenance pertinent to the AMH, manpower requirements, material lists, tools and equipment lists, quality assurance considerations, and, in some cases, maintenance level instructions for disposition of defective components that are beyond an activity's capabilities.


PUMP BYPASS FILTER
RELIEF VALVE
TO OVERBOARD DRAIN
RELIEF VALVE
MAIN RETURN FILTER
BUNO 149479 through 149482
BUNO 149483 and subsequent
FROM FLIGHT CONTROL CIRCUITS
BLEEDER VALVE
RESERVOIR
RELIEF VALVE
TO OVERBOARD DRAIN
AIR PRESSURE REGULATOR
HYDRAULIC PRESSURE INDICATOR
FROM COMBINED SYSTEM
TO COMBINED SYSTEM (SECONDARY SYSTEM)
SYSTEM RELIEF VALVE
ISOLATION VALVE
P-210
LANDING GEAR CONTROL PANEL
TO INTERIOR LIGHTING SYSTEM
ENGINE No. 1 (LEFT)
QUICK DISCONNECT
BLEEDER VALVE
CHECK VALVE
ISOLATION VALVE SW
FLT
S-618
LDG
L HYD PRESS
CB-53
1/2A
28V AC BUS
CB-52
1/2A
R HYD PRESS
FWD NOSE WHEEL WELL CB PANEL
7.5 A
CONTROLS
FWD NOSE WHEEL WELL CB PANEL
28V DC PRIMARY BUS
HYDRAULIC PUMP
QUICK DISCONNECT
CHECK VALVE
AIR PRESSURE GAGE
CHEMICAL AIR DRIER
QUICK DISCONNECT
AIR VALVE
ENGINE No. 2 (RIGHT)
SNUBBER
QUICK DISCONNECT (GROUND TEST SUPPLY CONNECTION)
PRESSURE TRANSMITTERS
ACCUMULATOR
Pressure
Return
Pneumatic Pressure
Supply
Flexible Hose
Vent or Drain Line
Mechanical Connection
Flow Direction
Free Flow
TO COMBINED SYSTEM RESERVOIR
CHECK VALVE
FROM ENGINE BLEED AIR
HYDRAULIC PUMP
SNUBBER
QUICK DISCONNECT (RESERVOIR FILL CONNECTION)
QUICK DISCONNECT (GROUND TEST PRESSURE CONNECTION)
CHECK VALVE
BYPASS FILTER
TO FLIGHT CONTROL CIRCUITS

216.35

Figure 6-3.—Flight hydraulic power system schematic (A-6A).

TROUBLESHOOTING/MALFUNCTION ANALYSIS

Troubleshooting is the logical or deductive reasoning procedure used when determining what unit is causing a particular system malfunction. The seven steps involved in troubleshooting are covered in chapter 10 of the *AMH 3 & 2 Rate Training Manual.* The Maintenance Instructions Manual for each aircraft generally provides troubleshooting aids that encompass these seven steps: (1) conduct a visual inspection, (2) conduct an operational check, (3) classify the trouble, (4) isolate the trouble, (5) locate the trouble, (6) correct the trouble, and (7) conduct a final operational check to certify that the trouble has been corrected. The various MIM's provide a variety of troubleshooting aids. Table 6-1 illustrates the troubleshooting chart used with the E-1B hydraulic power system. This type of chart supplies the trouble, probable cause, and the remedy for some of the more common malfunctions which cause the power system to become inoperative or uncontrollable. These charts are organized in a definite sequence under each possible trouble, according to the probability of failure and ease of investigation. In order to obtain maximum value from these charts, they should be used systematically in accordance with the aircraft manufacturer's recommendations.

Table 6-2 illustrates the troubleshooting table used with the A-6A flight hydraulic power system. The troubles in this table are numbered to correspond with the step of the operational check procedure where the trouble will become apparent.

Other MIM's utilize trouble analysis sheets to provide maintenance personnel with a means to logically pursue a trouble to a satisfactory solution by the process of elimination. The sympton is defined in tabular form with a remedy for each symptom. An example of trouble analysis sheets is provided in chapter 7, tables 7-2, 7-3, and 7-4. The sheets utilized with the checkout procedures relate to checkout procedures by direct reference or to discrepancies occurring in an operational environment (in-flight or ground operations). Each table provides a remedy for each symptom. When the remedy is as simple as replacing a component or making an adjustment, this is so stated. When the remedy requires further analysis, the entry in the REMEDY column will be a reference to an applicable paragraph, figure, or possibly another manual.

Each trouble analysis procedure provides preliminary data, such as tools and equipment, manpower requirements, materials, etc. The procedure is arranged in the order of most likely occurrence and contains a NO-YES column to direct the maintenanceman through a logical series of steps to isolate the malfunction. When the requirements of a step are satisfactory, refer to the YES column and perform the referenced step. When the requirements of a step are not satisfactory, refer to the NO column and perform the referenced step. This method is continued until the malfunction is isolated and corrected. The original checkout procedure must then be repeated to ensure that the malfunction has been corrected.

Diagrams

One of the more important factors in troublehsooting a system logically is having a complete knowledge of the sytem and how it operates. This involves the study of the information and associated schematics provided in the Maintenance Instructions Manual so that the function of each component and the results of that component malfunctioning can be utilized in the process of analyzing actual malfunction symptoms and thus distinguish between possible and probable troubles.

A primary concern in troubleshooting an aircraft hydraulic system is to determine whether the malfunction is caused by hydraulic, electrical, or mechanical failure. Since the actuating systems are dependent on the power systems, some of the troubles exhibited by an actuating system may be caused by difficulties in the power system. Conversely, a symptom indicated by a unit of the power system may be caused by leakage or malfunction of one of the actuating systems. When any part of the hydraulic system becomes inoperative, reference to the schematic diagram in conjunction with the checkout procedures provided in the aircraft MIM should result in methodical tracing of a

Table 6-1.—E-1B power system troubleshooting chart

Trouble	Probable cause	Remedy
Pump fails to deliver normal pressure.	Pump cavitating due to insufficient fluid in main reservoir.	Service reservoir.
	Incorrect pressure indication.	Check pressure indicating system.
	Relief valve sticking open.	Replace relief valve.
	Leak in the system.	Block off system beyond the relief valve and check pump pressure. If normal, locate leak and repair.
	Pump cavitating due to failure to fill pump case with fluid before installation.	Remove pump and fill with fluid.
	Maladjusted or defective pump.	Adjust pump on test stand, or replace.
Pump fails to deliver fluid.	Insufficient fluid in the main reservoir.	Service the reservoir.
	Air leak or plugged suction line.	Remove and check the suction line.
	Filters clogged.	Replace the filter elements.
	Check valves improperly installed.	Check for proper installation.
	Quick disconnects not properly tightened.	Check for proper installation.

difficulty to its source. Possible causes of trouble should always be eliminated systematically until the pertinent cause is found. No unit should be removed or adjusted, unless there is sound reason to believe the unit is faulty.

There are two classes of diagrams with which the AMH will be concerned in gaining a complete knowledge of a specific system and its operation. These are installation and schematic diagrams.

A diagram, whether it is an installation diagram or schematic diagram, may be defined as a graphic representation of an assembly or system, indicating the various parts and expressing the methods or principles of operation.

SCHEMATIC DIAGRAMS.—Figure 6-3 is an example of a schematic diagram of the flight hydraulic power system. Diagrams of this type do not indicate the location of the individual components in the aircraft, but do locate components with respect to each other within the system. As a general rule, the various components are indicated by symbols in schematic diagrams, while drawings of the actual components are used in the installation (pictorial) diagrams. The symbols utilized in the schematic diagrams conform to the military

Table 6-1.–E-1B power system troubleshooting chart–Continued

Trouble	Probable cause	Remedy
Pump fails to deliver fluid. (Continued)	Pump seizure because of contaminated fluid.	Flush system, replace filter elements, and pump.
	Pump seizure resulting in drive coupling shearing, from any of the above causes.	Check above remedies and replace the pump.
Pump delivers excessive pressure.	Incorrect pressure indication.	Check pressure indicating system.
	Maladjusted or defective pump.	Adjust pump on test stand, or replace.
Pump overheats.	Relief valve sticking open.	Replace relief valve.
	Pump compensator sticking, allowing pump to operate at full volume against excessive pressure.	Replace pump.
Pressure fluctuation.	Defective pressure transmitter.	Replace transmitter.
	Malfunctioning electrical system.	Check electrical system.
	Defective pressure gage.	Replace gage.
	Pump malfunctioning.	Replace pump.
External leakage at pump.	Shaft fluid seal damaged.	Replace pump.
Air in hydraulic system.	Suction line leaking or not properly connected.	Check the suction line.
System inoperative.	Pump failure.	Use external hydraulic power and check system operation. If normal operation is achieved, determine the cause of pump failure before installing new pump.
Chatter in system.	Air in system.	Operate system several times to return trapped air to the reservoir. Service main reservoir.
Line hammer.	Improper air charge in accumulator(s).	Relieve system pressure and service accumulator(s).
Accumulator pressure drops below normal.	Defective air filler valve.	Relieve hydraulic system pressure and accumulator air pressure and replace the air filler valve.
	Defective seal in the accumulator.	Replace all seals in the accumulator.

Table 6-2.—Troubleshooting flight hydraulic power system

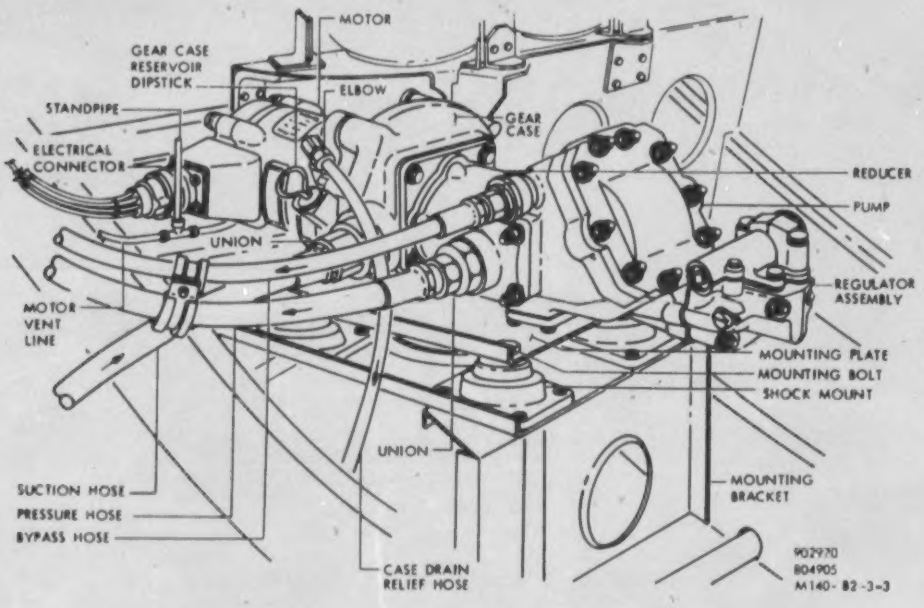
Probable cause	Isolation procedure	Remedy
STEP 3 TROUBLE: RESERVOIR FLUID LEVEL INDICATOR INDICATES BELOW FULL		
Reservoir fluid level low.	Check reservoir fluid level.	Service hydraulic system reservoir.
STEP 4 TROUBLE: FILTER DIFFERENTIAL PRESSURE INDICATOR BUTTON UP		
Indicator button not properly reset.	Manually reset indicator button.	Operate hydraulic power system. If normal operation results, no further action required. If indicator button pops, clean and/or replace filter element.
STEP 5 TROUBLE: SYSTEM HYDRAULIC PRESSURE FAILS TO DEPLETE		
Accumulator pressure gage defective.	Replace gage with a known operative gage.	If normal operation results after replacement, use replacement gage.
STEP 6 TROUBLE: ACCUMULATOR PRESSURE GAGE DOES NOT INDICATE 2,000 PSI		
Improper accumulator preload.	Deplete hydraulic system pressure, then check accumulator pressure preload.	Service accumulator preload.
Air filler valve.	Check air filler valve for leakage.	Retorque swivel nut or replace defective O-ring, defective filler valve.
Pneumatic lines.	Check pneumatic lines for leakage	Retorque or replace faulty pneumatic line section.
Accumulator pressure gage.	Replace gage with a known operative gage.	If normal operation results after replacement, use replacement gage.
Accumulator	Check accumulator for leakage.	Replace defective O-rings or defective accumulator.
STEP 8 TROUBLE: PILOT'S HYDRAULIC PRESSURE INDICATOR (UPPER LEFT DIAL) INDICATES BELOW 3,000 PSI		
Hydraulic lines.	Check hydraulic lines for leakage.	Retorque or replace faulty hydraulic line section.
Pilot's hydraulic pressure indicator.	Replace indicator with a known operative indicator. (Refer to NAVAIR 01-85 ADA-2-5.)	If normal operation results, after replacement, use replacement indicator.
Pressure transmitter.	Replace transmitter with a known operative transmitter. (Refer to NAVAIR 01-85ADA-2-5.)	If normal operation results, after replacement, use replacement transmitter.

standard mechanical symbols provided in MIL-STD-17B-1 and MIL-STD-17B-2. Most manufacturers improve upon these basic symbols by showing a cutaway portion on each component which aids in clarifying operation of that component. The maintenanceman is able to trace the flow of fluid from component to component. On most diagrams of this type a noncolored legend or different colors are used to represent the various lines identifying them in relation to their purpose and the mode of operation being represented. Each component is further identified by name, and its location within the system can be ascertained by noting which lines lead into and out of the component.

INSTALLATION DIAGRAMS.–Figure 6-4 is an example of an installation diagram. This is a diagram of the motor driven hydraulic pump installation of the P-3A aircraft. Installation diagrams show general location, function, and appearance of parts and assemblies. On some installation diagrams letters on the principal view (A, B, C, etc.) refer to a detailed view located elsewhere on the diagram. Each detail view is an enlarged drawing of a portion of the system identifying each of the principal components for purposes of clarification. Diagrams of this type are invaluable to maintenance personnel in identifying and locating components, and understanding the principle of operation of complicated systems.

ELECTRICAL SCHEMATICS.–Since many hydraulic systems are electrically controlled, the AMH should be capable of reading the electrical portion of the hydraulic schematic diagram as well as the hydraulic portion. Knowledge of the electrical symbols provided in the *AMH 3 & 2 Rate Training Manual* and the use of a multimeter in making voltage and continuity checks will contribute significantly to efficient troubleshooting. If it is determined that a malfunction is caused by electrical problems and not hydraulic or mechanical problems, the assistance of personnel within the AE rating will be required.

All electrical wiring in the aircraft is marked at specified intervals with a wire identification code. These identification codes are defined in


MOTOR
GEAR CASE RESERVOIR DIPSTICK
ELBOW
STANDPIPE
ELECTRICAL CONNECTOR
GEAR CASE
REDUCER
PUMP
UNION
REGULATOR ASSEMBLY
MOTOR VENT LINE
MOUNTING PLATE
MOUNTING BOLT
SHOCK MOUNT
UNION
MOUNTING BRACKET
SUCTION HOSE
PRESSURE HOSE
BYPASS HOSE
CASE DRAIN RELIEF HOSE
902970
804905
M140-82-3-3

216.36

Figure 6-4.–Installation diagram–motor driven hydraulic pump.

the electrical volume(s) of the Maintenance Instructions Manual and are useful in tracing wires throughout the aircraft to pinpoint an electrical malfunction. If an elusive malfunction is reasonably traced to or considered to be of an electrical nature, the electrical circuit should be checked by a qualified AE. Many wires can give a good continuity reading under a no-load or low current condition and still be malfunctioning when under a load condition.

Pressure Gage/Annunicator Panel Indications

All aircraft equipped with hydraulic power systems utilize some type of pressure indicating system to keep the pilot informed regarding the system's proper operation. Some aircraft also feature an annunicator panel (flashing warning light system) to get the pilot's attention and warn him of a failure or system malfunction. The usefulness of the pressure gage indications in troubleshooting the system will depend on the type of indicating system and the method used to control the system pressure.

In a closed center system that uses a pressure regulator for controlling system pressure, four different pressure indications are useful in determining improper system operation. These are indications above normal system pressure, zero pressure, below normal indications, and a fluctuating pressure indication.

The above normal indications are caused by the pressure regulator. If the pressure regulator does not cut out at the proper pressure, the pump will continue to build up pressure until either the relief valve relieves or the regulator cuts out at a higher pressure setting than normal. A regulator causing above normal pressure will most likely be out of adjustment or be stuck in the cut-in position.

Zero pressure indications can be caused by a number of things. Some of the causes are simple and obvious. For example, a broken pump shaft would seem like an obvious trouble because the pump would not be able to move any fluid to build up pressure. The use of a quick-disconnect troubleshooting pressure gage assembly will quickly pinpoint the trouble to the pump or indicate that the problem is elsewhere in the system. Since there are other factors that can prevent pressure buildup, consider all possibilities before attempting to remove any unit. Some other things that can cause a zero pressure reading are a pressure regulator stuck in the cut-out position, a major leak, low fluid level in the reservoir, system dump or bypass valve open, and a faulty indicating system.

If you suspect the pump is inoperative, pressurize the system with a portable hydraulic test stand and observe the system operation. If the system functions normally and the gages read normal, you will know beyond a doubt that the pump is the source of trouble. If the aircraft indicating system showed zero pressure with the test stand supplying pressure, a faulty indicating system would be suspected as a more logical cause for the zero pressure than a broken pump shaft.

Below normal pressure indications can be caused by a low setting of either the regulator or the relief valve and possibly by a leak. In most cases, a leak will be indicated by a fluctuating gage rather than a low-pressure reading. If the relief valve is set too low, fluid pressure never reaches the cut-out setting of the pressure regulator. If the regulator setting is too low, the pressure will cut out before the desired pressure is reached. By operating a subsystem and observing a pressure gage for a drop to cut in pressure, then a buildup to a cut-out pressure, the trouble can usually be isolated to either the regulator or the relief valve.

As previously stated, a fluctuating gage generally indicates a leak in the system. The leak could be external or internal. The escaping fluid causes the pressure to drop, thus causing the regulator to cut in and cut out to maintain pressure. The use of the gages in troubleshooting a system without a pressure regulator, one in which the pressure is controlled by a mechanism within the pump, will vary from that utilizing one with a pressure regulator. The importance of gage indications in troubleshooting can be readily seen by reviewing the trouble indications listed in tables 6-1 and 6-2.

Testing and Operational Checks

Hydraulic tests and operational checks should be performed under conditions as nearly operational as possible. Such test or checks should be performed in accordance with the instructions outlined in the applicable Maintenance Instructions Manual. The operational check should be made in the sequence outlined in the MIM, and any discrepancies noted when performing a step should be corrected before proceeding. In most MIMs the operational check and the troubleshooting charts have been coordinated so that malfunctions can be isolated in an efficient manner. If the troubleshooting aids do not list the trouble being experienced, the maintenanceman will have to study the hydraulic schematics, perform the operational check, and utilize logic and common sense in pinpointing the cause of malfunction. The test stand to be used in performing the operational check must be capable of producing the required flow and pressure required for proper operation. All electrical switches and circuit breakers, as well as hydraulic selector valves, should be checked for proper position prior to applying external electrical and hydraulic power. All maintenance must be performed in accordance with the Maintenance Instructions Manual, observing all maintenance precautions and requirements for quality assurance verification.

Personnel involved in troubleshooting and performing operational checks will often find it helpful to consult the records maintained in maintenance control and/or the work center register for the aircraft being worked on. In such cases reference to records of previous maintenance may show a progressive deterioration of a particular system or a previous discrepancy that could be helpful in pinpointing the cause of the malfunction currently being experienced.

Leakage (Internal, External, and Allowable)

Almost all hydraulic failures can be included in one or more of the following categories–lack of fluid supply (and pressure), external leaks, internal leaks, or physically defective units.

EXTERNAL LEAKAGE.–External leaks are indicated by streaks or puddles of hydraulic fluid on or near the aircraft. Most external leakage can be attributed to incorrect installation procedures resulting in cross-threaded or stripped fittings, loose fittings, or improper preseating of sleeves and seals. Tightening fittings to the proper torque values will often stop leakage; but if the leak is not eliminated, the defective part must be removed or replaced in accordance with approved assembly procedures.

Some external leakage is allowed around most hydraulic unit shafts including pumps. This type leakage should be checked carefully in accordance with the instructions in the applicable Maintenance Instructions Manual prior to removing the unit for repairs. Most Maintenance Instructions Manuals specify a given number of drops of leakage over a certain length of time or over a specified number of cycles of operation.

INTERNAL LEAKAGE.–Internal leaks may be caused by fluid contamination or worn or defective units. Any condition within a unit that permits hydraulic fluid to escape into the system return lines will cause a drop in operating pressure. Sluggish or erratic operation of an actuating system is usually evidence of internal leakage caused by worn or deteriorated O-rings or an unseated valve.

Locating an internal leak is often a difficult procedure. A thorough and complete knowledge of the entire hydraulic system and its operation is necessary. Reference to the schematic diagrams and troubleshooting charts, and a methodical process of elimination will usually result in isolation of the defective unit. When the leak has been located, the unit should be removed and repaired or replaced.

To avoid unnecessary replacement of hydraulic units and minimize maintenance on hydraulic systems, certain factors must be considered before system components suspected of leakage are rejected. In a check of a report of hydraulic leak, the possibility that hydraulic fluid may have been spilled during previous maintenance and was not properly wiped up should be considered. This fluid may drip or run into various areas or units and later become apparent and mistaken for new leakage.

Seepage of hydraulic fluid around seals is characteristic of many hydraulic components and may be defined as a trace of hydraulic fluid, or wetting of a surface which cannot be measured. Such seepage is acceptable within certain limits as normally specified in the applicable MIM, and, in some cases, is necessary for lubrication purposes at gland nuts or units with a moving piston. Accumulated seepage is often mistaken for leakage. The amount of seepage is often proportional to the length of time the unit has been idle. Under static (no pressure) conditions, O-rings and seals within units tend to temporarily shrink in diameter. This action, plus small irregularities within the seals, sometimes allows considerable seepage either to pass the seals and appear as leakage or to collect in cavities or seal grooves and be forced out when the unit begins to operate under pressure. A few operational cycles of the unit generally restores the O-ring or seal to its original shape, and what appears to be a leakage stops.

Because of the design characteristics of seals and O-rings, a small amount of leakage during operation of units is acceptable. Whenever the leakage exceeds the limits specified in the MIM, the unit is considered unserviceable and must be repaired or replaced. In the absence of acceptable leakage charts in the applicable MIM, the amount of small leakage with regard to acceptability may present a problem. Leakage appearing as droplets at gland nuts, cylinder ends, and vent holes should be checked under static and dynamic pressure conditions to stabilize the actual leakage rate.

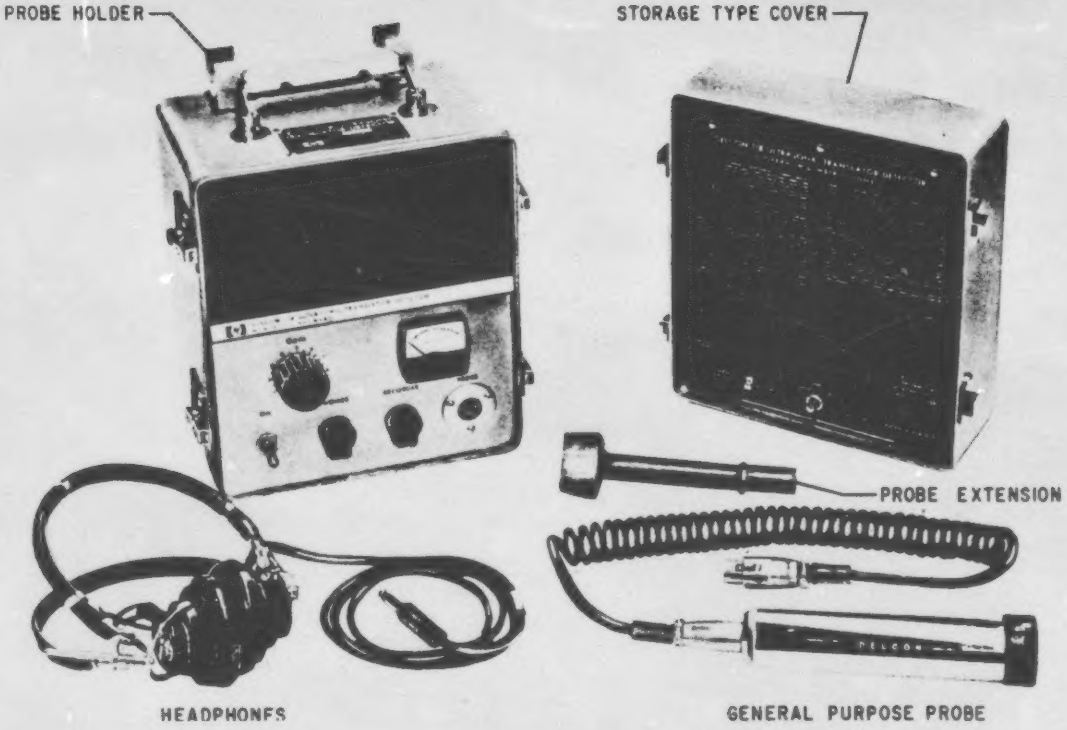
ULTRANSONIC LEAK DETECTION TRANSLATOR.–One of the latest methods of detecting leaks, both internal and external, is the use of an ultrasonic leak detection translator. Ultrasonic sound waves are created by such things as pressure or vacuum leaks, mechanical friction, high-voltage arcing, etc. The ultrasonic leak detector makes it possible to pinpoint such leaks or troubles by translating the high-frequency inaudible sound waves into the audible range of human hearing and provides an accompanying needle deflection on the device's sound intensity meter.

Figure 6-5 illustrates the Model 4918A Ultrasonic Translator utilized by many fleet maintenance activities. This instrument operates on mercury cell batteries and offers complete field portability. The ON-OFF switch turns on battery power to the instrument. Before the cabinet cover can be installed, the switch must be in the OFF position. With the ON-OFF switch in the ON position and the probe and the headphones plugged into their respective jacks, the instrument is ready for use. The gain control knob controls the amount of amplification of sound and the degree of accompanying needle deflection.

There are several applications for the use of the ultrasonic detector in the maintenance of hydraulic systems. Some of these also apply to its use in pneumatic and electrical system maintenance. The general purpose probe has proven extremely effective in pinpointing external leaks in complex hydraulic plumbing. While most hydraulic leaks produce readily visible signs that lead to their visual detection, some pinhole leaks allow fluid to escape in an atomized mist and form a pool of fluid remote from the actual leak area. The detector with the general purpose probe will detect the shrill ultrasonic hissing of fluid at its source and pinpoint the leak.

The general purpose probe is also reponsive to the interaction of higher velocity air or gas molecules with the atmosphere. The ultrasonic hissing sound caused by such interaction is detected, and the pressure or vacuum leak can be quickly pinpointed. Experience in interpreting pulsed or rhythmic sounds detected by the probe can result in its use in detecting certain mechanical malfunctions. Frying sounds caused by electrical arcing can also be detected. The probe extension (fig. 6-5) provides access to hard-to-reach crevices with greater probe sensitivity.

The contact probe, illustrated in figure 6-6, adds a greater range of sensitivity and responsiveness to the ultrasonic translator when it is being used to locate unusual fluid flow in hydraulic components. By placing the contact probe against a suspected valve, the rushing sound can be compared (by sound level and needle deflection) with the sound of a known good component, and a reasonable determination may be made concerning whether or not the component is malfunctioning. See fig. 6-7. This will prevent unnecessary breaking into a system to isolate the malfunctioning


PROBE HOLDER
STORAGE TYPE COVER
PROBE EXTENSION
DELCON
HEADPHONES
GENERAL PURPOSE PROBE

216.37

Figure 6-5.–Ultrasonic leak detection translator.

component and decrease the possibility of contamination.

The contact probe cannot respond to acoustic energy of any level transmitted through the atmosphere so its detection capability is limited strictly to the ultrasonic energy released within the metal structure it is placed against.

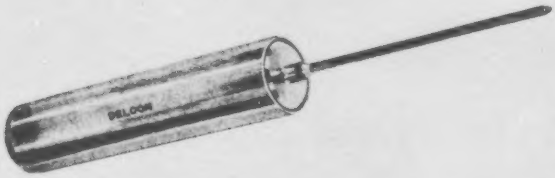


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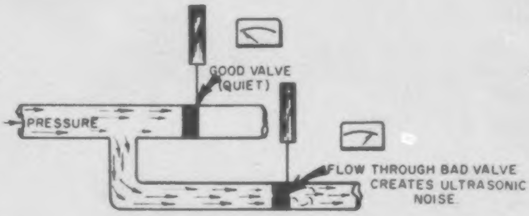
Figure 6-6.–Contact probe.

For the maintenanceman, this means his inspection with the probe is pinpointed to the precise area of interest. The probe responds to the seemingly infinitesimal mechanical vibration conducted from the ultrasonic source through


GOOD VALVE
(QUIET)
PRESSURE
FLOW THROUGH BAD VALVE
CREATES ULTRASONIC
NOISE

216.39

Figure 6-7.–Locating an internal leak with a contact probe.

the structure. This mechanical energy is in turn conducted through the probe stylus to a crystal within the probe housing. This crystal transducer converts the mechanical energy into an electrical signal which is amplified and results in a needle deflection on the intensity meter and an audible sound in the headset.

The ultrasonic detector can save many maintenance manhours when used to its full capability. For example, in locating a leak in pneumatic or hydraulic systems with long runs of plumbing, the detector probe can be run along the tubing run, outside of the aircraft skin, and the general area of the leak may be pinpointed without removing numerous panels. The advantage of this capability in pinpointing an elusive leak should be obvious.

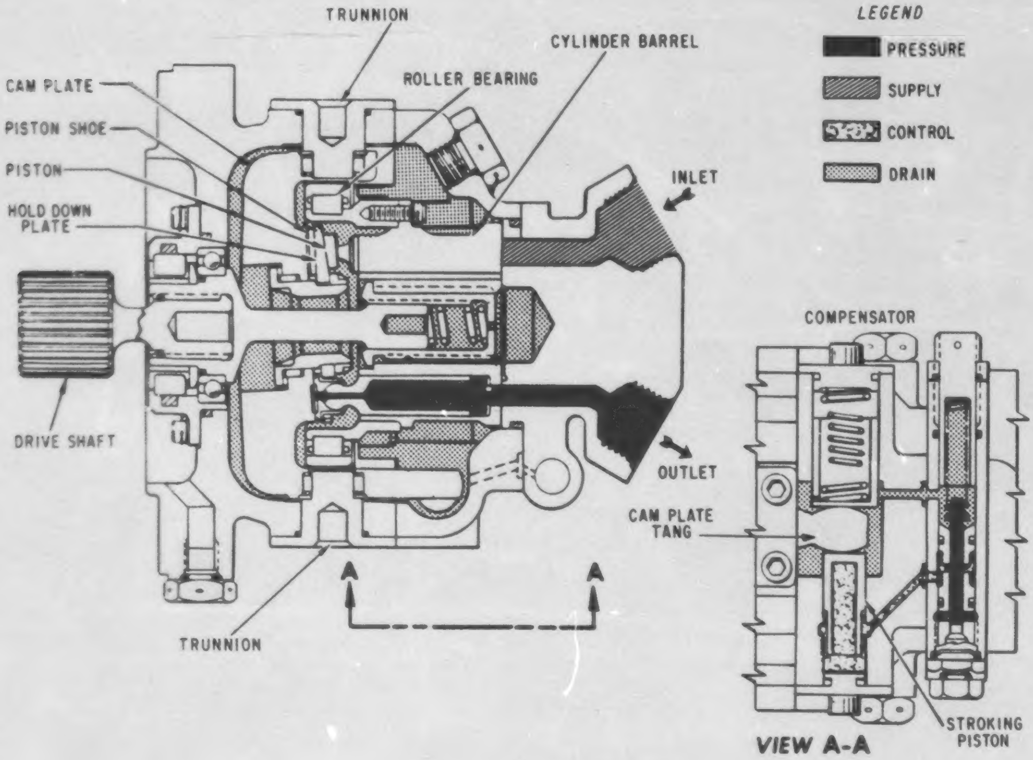
REMOVAL AND INSTALLATION OF COMPONENTS

All hydraulic equipment should be removed and installed in accordance with the procedures provided in the applicable Maintenance Instructions Manual or, in the absence of such instructions, in accordance with acceptable shop practices. The following information is general and may be used during most aircraft hydraulic systems repairs:

1. Prior to removing equipment, fittings, or lines, make certain all hydraulic pressure has been bled from the hydraulic system and electrical power is not connected to the aircraft.
2. Provide a suitable container for drainage of lines during the removal of components. The use of barrier-type waterproof paper or a water-soaked cloth beneath opened lines will prevent fluid from dripping on electrical wiring and aircraft surfaces. The defective unit being returned to supply should be flushed with preservative-type hydraulic fluid, drip-drained, and all ports capped or plugged.
3. When removing equipment, disconnect any electrical wiring and mechanical linkage as necessary. A dust cap should be placed over the end of the electrical connector halves, and mechanical linkage should be secured to prevent damage or personnel hazard. Since most hydraulic units operate with close tolerance in all moving parts, it is imperative that the unit and the system be protected from possible contamination. When lines are open, or hydraulic units are removed, use clean caps and plugs as appropriate to close the openings. Use flared plugs on flared tubing connections and flareless type on flareless tubing connections. They are not interchangeable. Do not use rags or other makeshift devices. On units with flexible hoses, do not use the hose as a handle for picking up the part. Do not bend any hoses to smaller than their specified bend radius, as this will damage the hose liner.
4. When separating hydraulic lines and fittings, use care to prevent damage to flares and fittings. Most units will not come equipped with the various fittings required for their installation. Before removal of fittings from the unit being replaced, the location and position of each should be recorded to aid in correctly installing them in the replacement component.
5. When connecting lines and fittings, do not overtighten. Overtightening may cause the fitting to yield and damage the connection. If a leak is encountered at a connection, loosen the connection to allow a slight flushing of the mating surfaces and retighten in accordance with the torque tables found in the applicable MIM.
6. When replacing lines through pressure bulkheads or other seals, carefully inspect seals for damage and repair or replace if necessary.
7. When the installation is complete, the affected system should be bled and tested for leakage and proper operation as specified in the applicable MIM.
8. When working with equipment of one system which is located near identical and interchangeable equipment of another system, care should be taken to ensure that all lines are properly connected for system continuity.

HYDRAULIC PUMPS

All aircraft hydraulic systems have one or more power driven pumps. These power pumps may be either engine-driven or electric motor-driven. The electric motor-driven pumps are normally used in emergency hydraulic systems; however, one late model patrol aircraft has electric motor-driven pumps to supply both the normal and emergency systems. Several


TRUNNION
CYLINDER BARREL
ROLLER BEARING
CAM PLATE
PISTON SHOE
PISTON
HOLD DOWN PLATE
DRIVE SHAFT
INLET
OUTLET
CAM PLATE TANG
TRUNNION
A
A
LEGEND
PRESSURE
SUPPLY
CONTROL
DRAIN
COMPENSATOR
STROKING PISTON
VIEW A-A

216.49

Figure 6-8.—Variable displacement engine-driven pump (Kellog).

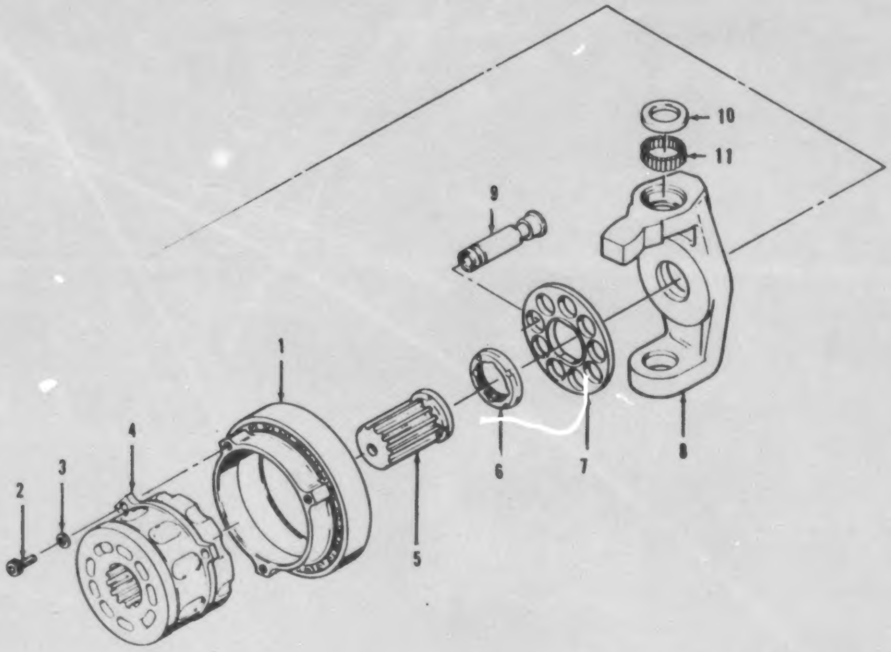
types of pumps are discussed in chapter 6 of *AMH 3 & 2 Rate Training Manual.* Additional pump coverage is provided in the following paragraphs.

KELLOG VARIABLE DISPLACEMENT PUMP (ENGINE DRIVEN)

The variable displacement, constant pressure type, engine-driven pump illustrated in figure 6-8 is similar to the one used in the A-5. This particular model is a nine-piston rotary type pump with a rated capacity of 15 gallons per minute at 3,680 rpm. Normal delivery pressure is 3,000 psi maximum. The pump delivers full flow volume at all pressures up to 2,900 psi, then the rate of flow decreases beyond that point as pressure increases until pump delivery at 3,000 psi is 0 gpm.

The pump consists of three major component groups—cylinder barrel and piston group, pressure compensator, and the housing group. Figure 6-9 provides a dissassembled view of the cylinder barrel and piston assembly.

The cylinder barrel is face ported and is supported in the pump body by the single large diameter roller bearing. Rotation of the cylinder barrel is accomplished through the internal drive shaft, which passes through the inclined cam plate. The pistons, which are supported on the inclined cam plate by hydraulically balanced shoes, are reciprocated into the bores by the inclined cam plate and retracted by the holddown plate.



1. Barrel assembly bearing.
2. Barrel holddown screw (3) (to inner race of bearing).
3. Washer (3).
4. Cylinder barrel.
5. Barrel drive bushing.
6. Holddown nut.
7. Holddown plate.
8. Hanger.
9. Piston and shoe assembly.
10. Trunnion washer.
11. Needle bearing.

216.50

Figure 6-9.—Cylinder barrel and piston group with bearing and hanger assembly.

Rotation of the cylinder barrel aligns the high-pressure ports, and the pumping action is completed as the pistons are forced inward by the inclined cam plate. The maximum discharge pressure developed by the pump is limited and controlled by the pressure actuated compensator shown in view A-A, figure 6-8. Controlled pressure from the compensator actuates the stroking piston, which varies the cam plate angle. Sufficient cam plate angle is maintained under all flow conditions within the range of the pump to allow the pump to develop maximum rated pressure.

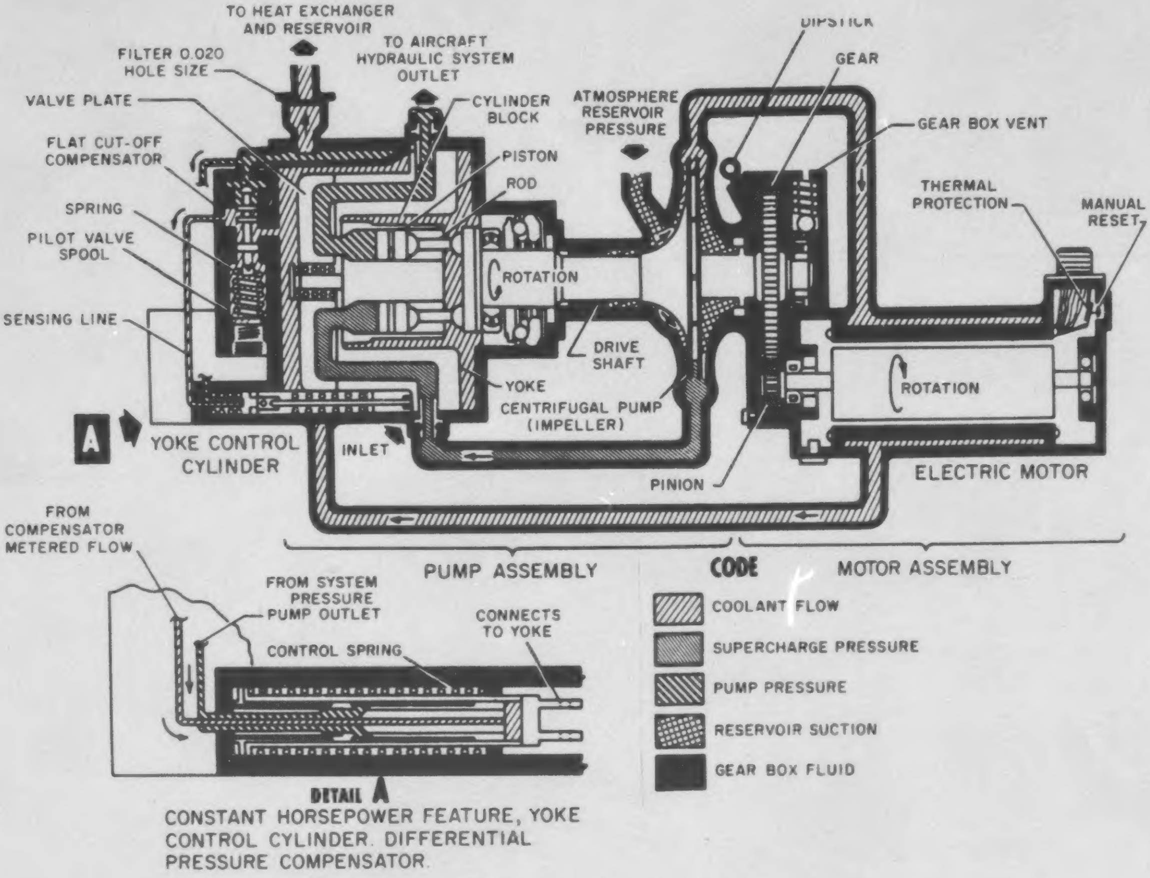
The compensator action consists of the following action. System pressure is directed to the compensator valve and spool, which is held in position by an adjustable spring. When system pressure exceeds the spring load on the spool, the spool moves to admit hydraulic fluid to the stroking cylinder piston. The piston in turn moves the angle plate to a lesser angle, reducing pump fluid intake and subsequent volume delivered sufficiently to maintain the desired system pressure. When system pressure is less than spool spring load, the spool moves to bypass the oil in the stroking cylinder piston to the pump case drain. The piston then moves the pump angle plate to increase pump fluid intake and volume output.

VICKERS VARIABLE DISPLACEMENT PUMP

There is a variety of Vickers variable displacement hydraulic pumps in use on naval aircraft. The pump assembly shown schematically in figure 6-10 is one of the newest Vickers variable pumps. The P-3A aircraft, which has no engine-driven pumps, has three of these electric motor-driven pumps to supply normal hydraulic system pressure.

The variable pump used in this installation is a reciprocating, variable volume and displacement, nine-piston axial type pump. This pump has three ports: INLET, OUTLET, and CASE DRAIN (BYPASS). The operating pressure is 3,000 psi with an 8-gpm capacity at rated speed. Rated flows of the variable pump are as follows–8 gpm from 0 to 2,200 psi; 6 gpm at 2,950 psi; 0 gpm at 3,000 psi.

The motor is a continuous duty, ac induction motor with a shaft speed of 12,000 rpm (full load speed of 11,300 rpm). The motor


TO HEAT EXCHANGER AND RESERVOIR
TO AIRCRAFT HYDRAULIC SYSTEM OUTLET
FILTER 0.020 HOLE SIZE
VALVE PLATE
CYLINDER BLOCK
ATMOSPHERE RESERVOIR PRESSURE
DIPSTICK
GEAR
GEAR BOX VENT
FLAT CUT-OFF COMPENSATOR
PISTON
ROD
SPRING
PILOT VALVE SPOOL
THERMAL PROTECTION
MANUAL RESET
ROTATION
SENSING LINE
DRIVE SHAFT
YOKE
CENTRIFUGAL PUMP (IMPELLER)
ROTATION
A
YOKE CONTROL CYLINDER
INLET
PINION
ELECTRIC MOTOR
FROM COMPENSATOR METERED FLOW
PUMP ASSEMBLY
MOTOR ASSEMBLY
FROM SYSTEM PRESSURE PUMP OUTLET
CONNECTS TO YOKE
CONTROL SPRING
CODE
▨ COOLANT FLOW
▨ SUPERCHARGE PRESSURE
▨ PUMP PRESSURE
▨ RESERVOIR SUCTION
■ GEAR BOX FLUID
DETAIL A
CONSTANT HORSEPOWER FEATURE, YOKE CONTROL CYLINDER. DIFFERENTIAL PRESSURE COMPENSATOR.

216.51

Figure 6-10.–Electric motor-driven variable displacement hydraulic pump.

drives both the variable pump and a centrifugal pump. The motor is fully enclosed and is cooled by a flow of hydraulic fluid from the integral centrifugal pump. See fig. 6-10. The centrifugal pump is also used to pressurize (supercharge) the inlet fluid to the variable pump.

The variable displacement pump used in this installation consists of a drive shaft, bearings, pistons and rods, cylinder block, and a universal link. The drive shaft and cylinder block rotate at the same speed. The cylinder block angular position is variable in relation to the drive shaft. The greater the angle, the greater is the pump displacement. The angular relationship between the cylinder block and drive shaft is changed by positioning the yoke. The yoke position is regulated by the control spring and pressure, and horsepower control is regulated by the control cylinder.

Fluid enters the pump through the INLET and through the yoke and valve plate into the cylinder block. The inlet port in the valve plate is located in such a manner that the pistons are moving down (away from the valve plate) when their respective cylinder block ports rotate by the valve plate inlet port. This action allows fluid to pass into the cylinder bores. As the rotation continues, the cylinder block ports move to the valve plate OUTLET port. During this half of the cycle, the pistons are moving up in their bores when passing this port. This action forces fluid from the bores through the valve plate, yoke, and OUTLET port.

The yoke position (which controls displacement) is regulated as a function of the variable pump outlet pressure. The pressure compensator and the yoke control cylinder function as follows:

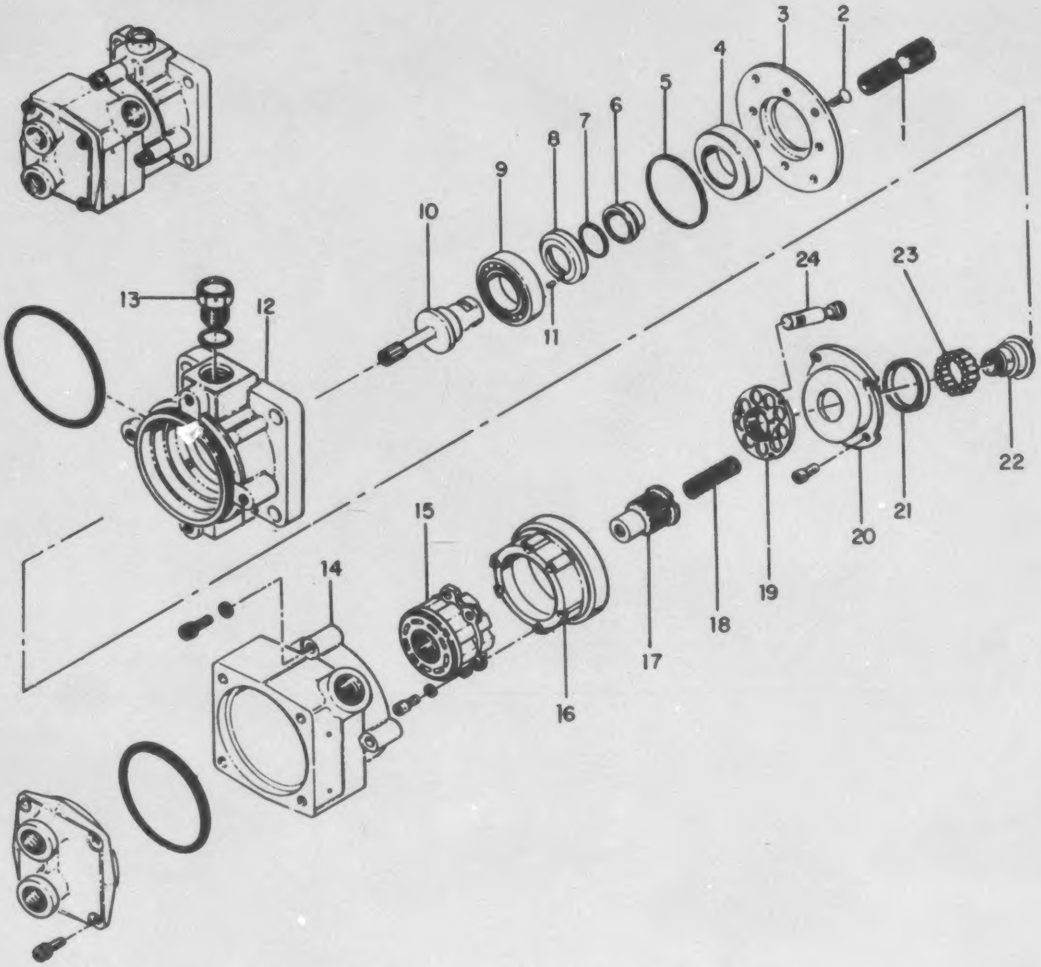
A passage is drilled into the variable pump outlet to sense hydraulic fluid pressure directly for the flat cutoff compensator and the yoke control cylinder. Between 0- and 2,200-psi pump outlet pressure (8 gpm), the pump yoke assembly remains at 30 degrees maximum (full displacement). In this condition, hydraulic fluid pressure in the sensing line from the pump OUTLET to either the compensator or yoke control is not sufficient to overcome spring force of either item; hence, these two items remain closed.

Between 2,200- and 2,950-psi pump outlet pressure, the constant horsepower control provides a linear reduction in displacement (8- to 6-gpm flow), and the pump yoke assembly begins to move toward the feathered (zero stroke) position. The control cylinder is mechanically linked to the yoke, and the displacement is reduced. At 2,950 psi, the yoke angle is between 20 and 25 degrees from the feathered position. In this condition, the yoke control cylinder spring begins to compress and allow movement of the yoke assembly toward the feathered position. The yoke control cylinder spring force at 2,200 psi is approximately 22 pounds, and at 2,950 psi it is approximately 43 pounds, as the spring is being compressed. The yoke control cylinder moves approximately 0.24 inch between these two spring values to place the pump yoke at approximately 24 degrees.

Between 2,950-psi and 3,000-psi pump outlet pressure, the pressure control acts to reduce displacement (6- to 0-gpm flow), and the pump yoke assembly will assume the full feathered position (zero degrees). However, the yoke will stop short of zero degrees and retain a position or angle sufficient to maintain 3,000 psi and make up for internal leakage within the pump. The yoke assembly will move approximately 0.580 inch from 2,950- to 3,000-psi pressure. In addition to hydraulic fluid pressure acting on the yoke control cylinder piston, the compensator spring force is overcome at 2,950 psi, and additional fluid force reacts on the large area of the yoke control cylinder piston. These combined fluid forces (compensator and yoke control) tend to feather the variable pump.

HYDRAULIC MOTORS

The hydraulic motor illustrated in figure 6-11 is representative of many commonly used in naval aircraft and is similar in general design and construction to the constant displacement, piston type pumps used in many auxiliary hydraulic systems. A hydraulic motor is used in several flap and slat arrangements where it is desirable to convert hydraulic pressure into rotary mechanical motion.



1. **External drive shaft.**
2. **Screw.**
3. **Seal retainer.**
4. **Shaft seal.**
5. **Preformed packing.**
6. **Shaft sleeve.**
7. **Preformed packing.**
8. **Mating face seal.**
9. **Ball bearing**
10. **Internal drive shaft.**
11. **Shaft seal pin.**
12. **Mounting flange.**
13. **Plug and bleeder.**
14. **Front housing.**
15. **Cylinder barrel.**
16. **Cylinder barrel bearing assy.**
17. **Barrel spline bushing.**
18. **Compression spring.**
19. **Holddown plate.**
20. **Cam plate.**
21. **Thrust washer.**
22. **Holddown bearing retainer.**
23. **Needle bearing.**
24. **Piston and shoe subassembly.**

216.52

Figure 6-11.—Fluid motor assembly.

By directing fluid already under pressure into one of the ports, this pressure will force the motor shaft to rotate, then pass out the return port. By attaching a torque tube or jackscrew arrangement to the drive shaft of the motor, rotary mechanical motion may be obtained.

The motor may be operated in either direction of rotation merely by controlling the direction of fluid flow to the valve plate ports. The direction of flow is controlled by a selector valve, and the direction of rotation may be instantly changed without damaging the motor. Many motors feature a hydraulic brake which stops action immediately when fluid flow is stopped.

The motor illustrated in figure 6-11 is a nine-cylinder, fixed diaplacement (stroke) type. It is self-lubricating and requires no daily maintenance. Removal and replacement and any miscellaneous parts replacement authorized at the intermediate level of maintenance should be performed in accordance with the instructions supplied in the Intermediate Repair Section of the MIM or 03 Manual.

HYDRAULIC PUMP MAINTENANCE

Hydraulic pump maintenance at the organizational level activity is generally limited to operational checks and checking for leaks and malfunctions. Malfunctioning pumps should be removed from the aircraft and replaced. Pressure compensator adjustment on the aircraft is generally prohibited but is allowed on some models of aircraft, such as the A-4E. Always consult the applicable MIM.

Removal/Parts Replacement and Installation

When removing hydraulic pumps or other hydraulic components, prevent dirt, lint, or any foreign matter from entering the component or lines. Discharge hydraulic systems residual pressure as well as reservoir pressure.

If a hydraulic connection is loosened with residual pressure on the system, serious injury to personnel and equipment could result. An atomized spray of hydraulic fluid has a flashpoint that may be lower than the operating temperature of some aircraft components; therefore, the possibility of igniting such a spray should be considered.

Clean the exposed surface of the fitting with a clean lint-free cloth before separating a line or fitting. If the area around the fitting or connection is dirty, flush with a suitable solvent (Freon) prior to breaking the connection. Drain the fluid from disconnected lines into a suitable container for disposal. Install clean protective plugs or caps on all openings, lines, and when applicable, electrical connectors. If the pump being removed is not to be reinstalled or if it is to be sent to the AIMD or depot level maintenance for overhaul and repair, flush it with preservative hydraulic fluid, allow it to drip drain, and install protective plugs and caps.

The following paragraph describes the procedures outlined for removal and installation of the engine-driven pump on the A-6A. Two men are required to remove the pump. After gaining access to the pump, disconnect the bypass line, suction line, and the pressure line in that order. The sequence is necessary to prevent unnecessary loss of fluid from the reservoir. Next loosen and remove the clamp securing the electrical bundle to the pump flange. Make a mark on the mounting pad so that the clamp may be returned to the same stud. Disconnect the constant speed drive cannon plug and swing the electrical bundle away to provide clearance for pump removal. One man supports the pump while the other removes the remaining mounting nuts and washers. Carefully move the pump off the engine mounting studs, taking care not to damage the drive shaft splines. If the drive shaft has been severed, it may be necessary to utilize a magnetic tool to withdrawn the broken splined shaft from its cavity. After removing the pump, remove and discard the mount gasket. Always ensure that the new pump is an identical part or an acceptable substitute. Ensure that all fittings and plugs are properly installed and safety wired as applicable.

Installation consists of applying a light coat of high-temperature aircraft grease to the replacement pump drive shaft splines. Install a new mount gasket and position the pump on the studs of the mounting pad. Install the securing nuts and washers, with the electrical bundle on the marked stud. With the pump still supported, torque the mounting bolts to the torque specified in the Maintenance Instructions Manual. Connect the CSD cannon plug and safety wire if applicable. Connect the pressure, suction, and bypass lines in that order. If the requirement to change a pump was not due to pump failure, service the reservoir in accordance with the servicing instructions provided in the General Information and Servicing volume of the Maintenance Instructions Manual. A complete operational check of the hydraulic power system should be made to determine if the new pump is operating properly and free from leakage.

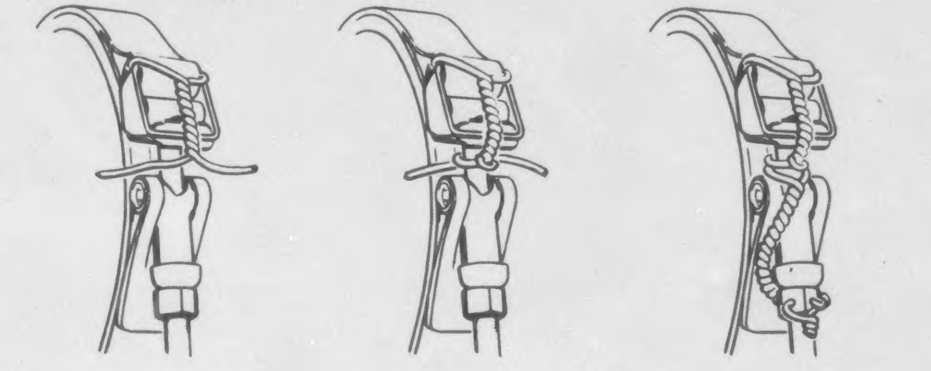
On some late model aircraft, the aircraft pumps are not mounted with bolts or on studs. Instead, the pump is mounted to an adapter and secured with a V-band clamp. The A-7 aircraft utilizes this type of mounting. Proper mounting of the pump to the adapter and proper torquing of the V-band are extremely important. On the A-7 the clamp nut is torqued to 55 to 66 inch-pounds. Then the clamp is tapped lightly with a soft mallet all the way around the clamp. This is followed by a retorquing of the clamp nut to ensure proper torque.

It may be necessary to alternately tap on the clamp and tighten until the torque indicated on the wrench stabilizes at the specified value. Exercise complete caution to avoid overtorquing. To prevent complete separation of the joint in the event the T-bolt of the V-band breaks, lockwire the coupling as illustrated in figure 6-12. The torque values specified for most standard aircraft nuts and bolts do not apply to V-band clamps. Values for these clamps are considered special torque values, and the amount of torque applied should conform to the applicable Maintenance Instructions Manual.

Miscellaneous parts replacement and cure date seal replacement that do not require complete disassembly are allowed on some aircraft pumps and motors at the intermediate level of maintenance. The pump must be bench tested following partial disassembly and repair to certify proper operation. The repairs and testing will always be in accordance with the applicable MIM or 03 Overhaul Manual.

System Servicing Following Pump Failure

Every Maintenance Instructions Manual provides special instructions for servicing the hydraulic system when the aircraft has experienced a pump failure. The hydraulic pump is a major contributor to internal system



1. LOOP LOCKWIRE THROUGH UPPER SECTION OF CLAMP AND TWIST UNTIL ALIGNED WITH BOLT SHOULDER, THEREBY LOCKING CLAMP IN CLOSED POSITION.
2. DOUBLE LOCKWIRE BACK TO FRONT OF BOLT AND TWIST SUFFICIENT AMOUNT TO ATTACH TO NUT.
3. ATTACH LOCKWIRE TO NUT, PULLING NUT TOWARD THE CLOCKWISE POSITION.

216.53

Figure 6-12.–Safetying a hydraulic pump V-band coupling.

contamination, and a pump failure can often introduce severe contamination that requires immediate attention prior to further flight.

On the A-6 aircraft, whenever one or more hydraulic pumps in a system have experienced a failure, both pumps in the affected system are removed and replaced. The pumps are tagged to indicate the type of failure and that repair is required (indicated on the Maintenance Action Form). The quick disconnects on the new pumps are not connected until the affected system has been flushed in accordance with the procedures provided in the MIM. Upon the completion of flushing, the reservoir is serviced and the engines operated to verify proper pump operation and check for leakage. The procedures to be followed following pump failure may vary dependent on the type and model of aircraft. In any case, consult the MIM and do not just replace the failed pump and assume that the system is not contaminated. The consequences of such action could be very costly. When connecting the quick disconnects on the pump lines, ensure that they are properly mated prior to tightening. If the disconnect leaks, check for O-ring damage and replace if necessary.

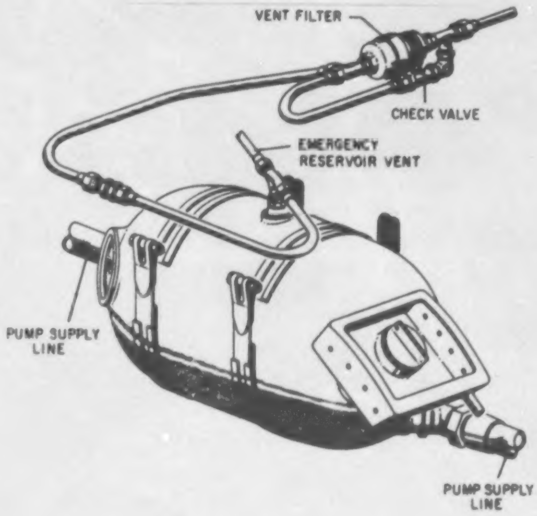
RESERVOIRS

Reservoirs are of two general types—non-pressurized and pressurized. Nonpressurized reservoirs are vented to the atmosphere to prevent a vacuum from being formed as the fluid level in the reservoir is lowered. The vent also makes it possible for any air that has entered the system to find a means of escape.

The reservoir in an aircraft which is designed for high-altitude operation is usually pressurized. Pressurizing assures a positive flow of fluid to the pump at altitudes where low atmospheric pressure is encountered.

Nonpressurized Reservoirs

The E-1B reservoir (fig. 6-13) is a representative example of the nonpressurized reservoir. This reservoir is a welded aluminum tank which is cylindrical with domed ends. The filler neck incorporates a removable 200-mesh metal screen assembly which serves as a filter. (NOTE: a 200-mesh metal screen has openings of 74 microns (0.0029 in.).)



216.54

Figure 6-13.—A nonpressurized reservoir.

A sight gage window for visual checking of the fluid level is located on the end of the reservoir. The rim of this window is marked with lines indicating the refill level.

The vent line is connected to the top of the reservoir (fig. 6-13) and leads to a vent filter (which has a replaceable micronic element) and a bypass check valve. This assembly functions to allow the air pressure in the reservoir to balance with atmospheric pressure and to filter the air which is drawn in when fluid is removed from the reservoir. The check valve allows air and hydraulic fluid to be expelled from the reservoir at a greater rate than normal when large volumes of fluid are returned to the reservoir, and it also prevents unfiltered air from being drawn into the reservoir.

The pump supply lines are attached to the reservoir at each lower end. The emergency and system return lines are attached to the side of the reservoir.

MAINTENANCE.—Maintenance of this reservoir consists mainly of testing for suspected leaks, cleaning the filler neck strainer, and replacement of the vent filter.

The filler neck strainer should be cleaned with drycleaning fluid (Stoddard solvent) periodically as specified in the applicable Maintenance Requirements Cards. When cleaning this strainer, inspect for broken mesh (sometimes the result of servicing with a funnel).

The vent filter element should be replaced in accordance with the instructions contained in the applicable Maintenance Instructions Manual. When reinstalling the filter, ensure that the end of the filter marked RES is secured to the line leading from the reservoir.

This reservoir may be tested for suspected leakage by the following procedure:

With the reservoir removed from the aircraft, plug all ports and record the various measurements of the reservoir.

Apply 8-psi internal hydrostatic pressure for 5 minutes. There should be no evidence of leakage, failure, or permanent set. There should be no change in the measurements that were recorded prior to applying the pressure.

After testing, the reservoir should be drip drained, and all openings should be plugged until installation.

When reinstalling the reservoir, all O-ring packings should be replaced.

Air-Pressurized Reservoirs

The A-5 No. 1 power system reservoir (fig. 6-14) is a representative example of an air-pressurized reservoir.

This reservoir consists of a shell (tank), a horizontal baffle, an inverted flight or negative g valve, a transparent sight gage, and a fluid level indicating probe. This unit, together with its pressurization and filling components, is shown schematically in figure 6-15.

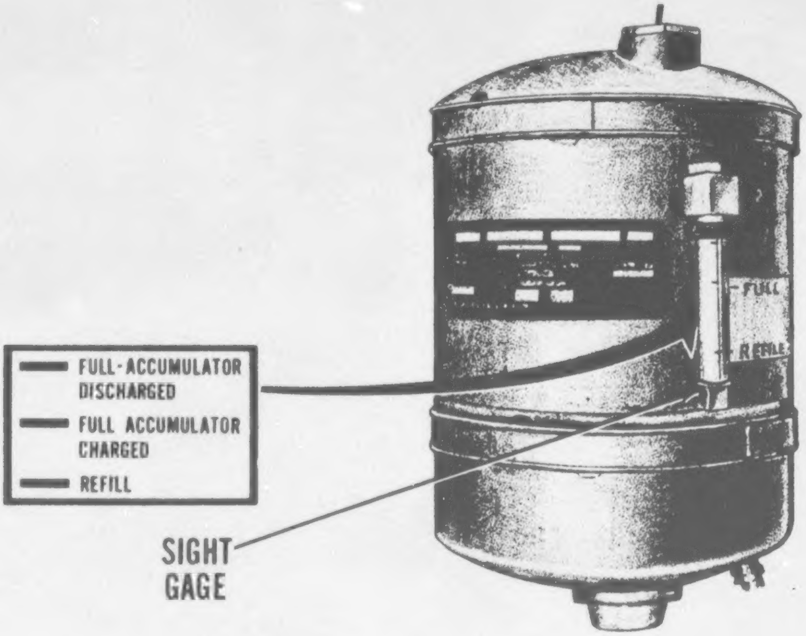


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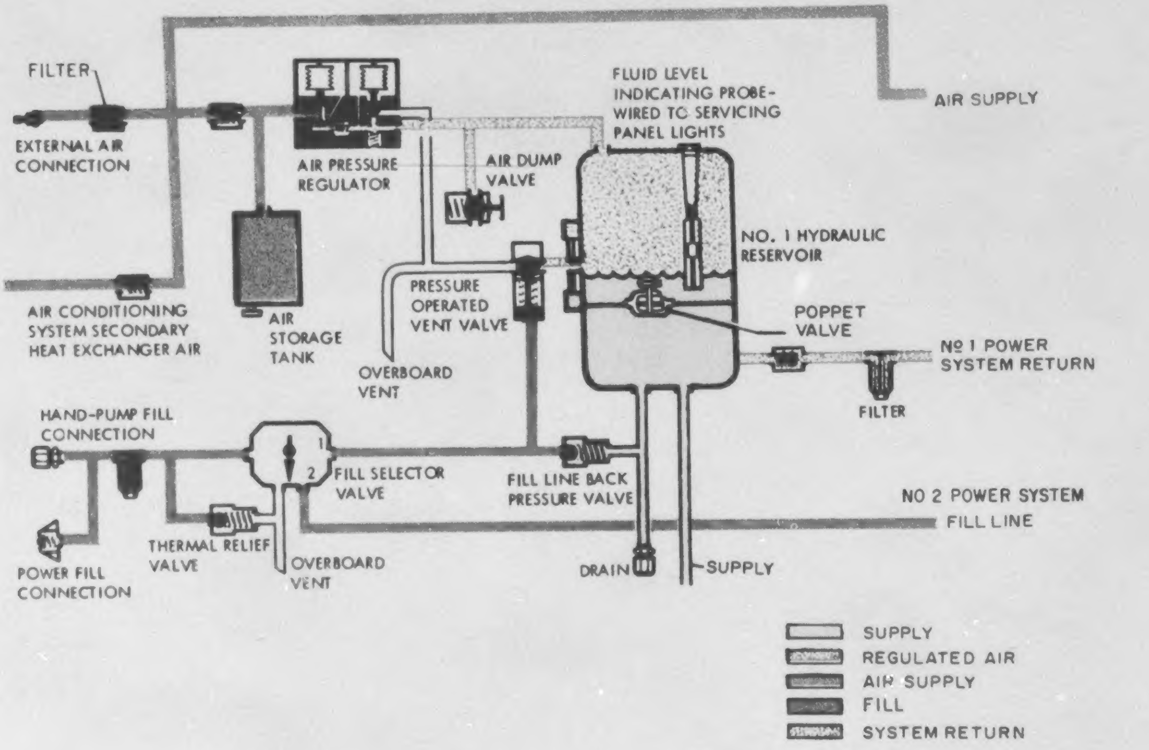
Figure 6-14.—Air-pressurized reservoir.


FILTER
EXTERNAL AIR CONNECTION
AIR PRESSURE REGULATOR
AIR DUMP VALVE
FLUID LEVEL INDICATING PROBE-WIRED TO SERVICING PANEL LIGHTS
AIR SUPPLY
NO. 1 HYDRAULIC RESERVOIR
AIR CONDITIONING SYSTEM SECONDARY HEAT EXCHANGER AIR
AIR STORAGE TANK
PRESSURE OPERATED VENT VALVE
POPPET VALVE
Nº 1 POWER SYSTEM RETURN
FILTER
OVERBOARD VENT
HAND-PUMP FILL CONNECTION
1
2
FILL SELECTOR VALVE
FILL LINE BACK PRESSURE VALVE
NO 2 POWER SYSTEM FILL LINE
THERMAL RELIEF VALVE
POWER FILL CONNECTION
OVERBOARD VENT
DRAIN
SUPPLY
SUPPLY
REGULATED AIR
AIR SUPPLY
FILL
SYSTEM RETURN

216.56

Figure 6-15.—Air-pressurized reservoir schematic.

The horizontal fluid-tight baffle divides the reservoir into two chambers to retain the hydraulic fluid over the pump outlet during short periods of inverted flight. The inverted flight or negative g valve on the horizontal fluid-tight baffle permits fluid flow between the upper and lower chambers during normal flight.

Hydraulic fluid from the power system return lines enters the lower chamber and is swirled (due to the construction of the return lines) to remove the air. The air present in the return fluid escapes into the upper chamber through the inverted flight or negative g valve.

The reservoir has a sight gage for visually checking the fluid level on the preflight inspection. A fluid level probe in the reservoir completes an electrical circuit which controls a reservoir fluid level light located on the pilot's instrument panel.

PRESSURIZATION.—The air pressure necessary to pressurize this reservoir is bled from the secondary heat exchanger. This air pressure is filtered, reduced, and maintained at a constant pressure of 75 to 85 psia.

The air pressurization system consists of an external air connection, an inline filter, two swing type check valves, an air pressure regulator, a dump valve, and an air stowage bottle.

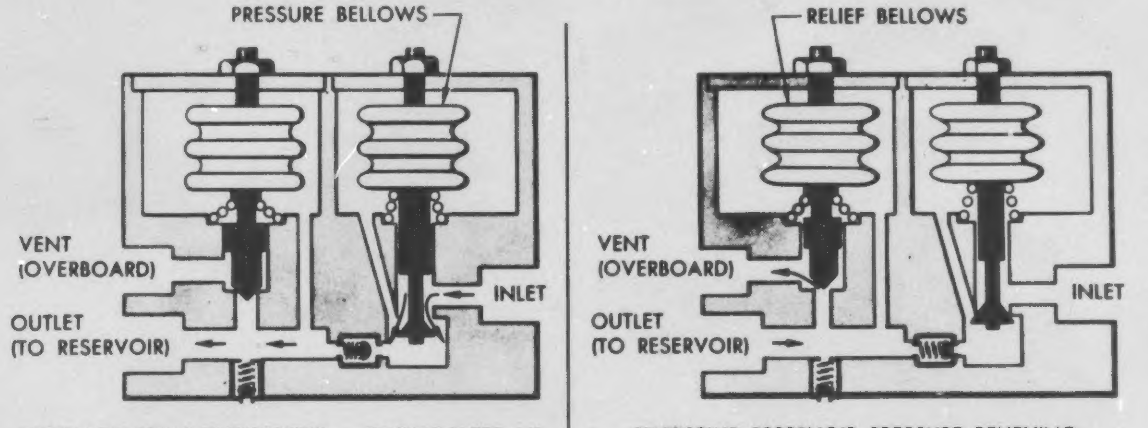
The external air connection is used to connect a source of external air pressure to the reservoir when ground testing the hydraulic power system with an external hydraulic power supply. This air connection is also used to pressurize the system after servicing the reservoirs. An inline air filter removes the foreign particles from the external air supply.

The stainless element in this filter must be removed and cleaned periodically.

The air pressure regulator controls and maintains a constant pressure of 75 to 85 psia in the reservoir to prevent pump cavitation. As the fluid level in the reservoir changes (through the operation of an actuating system), the regulator maintains a constant pressure by increasing airflow to the reservoir, or by venting excess reservoir air pressure overboard. The regulator has two bellows (fig. 6-16); one controls inlet pressure, the other provides relief to vent if the reservoir pressure increases. A vacuum relief valve is incorporated to permit airflow into the reservoir in the event of a negative pressure condition.

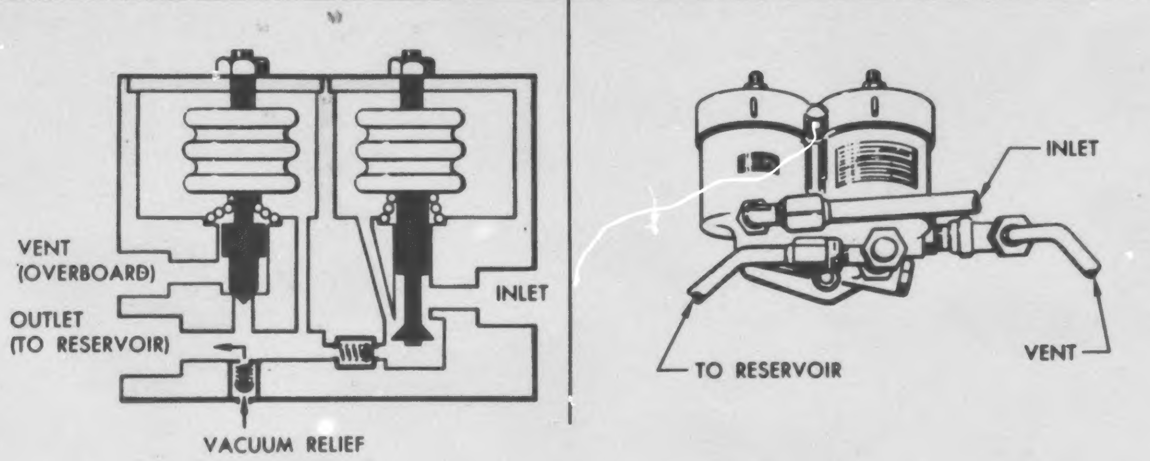
The reservoir pressurization system has a two-port, spring-loaded closed and manually opened dump valve. This dump valve is used to manually exhaust air pressure which is trapped in the reservoir prior to servicing the system.

FILLING PROVISIONS.–Provisions are incorporated to fill this reservoir from a single point. Filling is accomplished by connecting a clean source of filtered hydraulic fluid to either


PRESSURE BELLOWS
VENT (OVERBOARD)
INLET
OUTLET (TO RESERVOIR)
RELIEF BELLOWS
VENT (OVERBOARD)
INLET
OUTLET (TO RESERVOIR)

RESERVOIR BEING PRESSURIZED — ENGINE BLEED AIR

EXCESSIVE RESERVOIR PRESSURE RELIEVING


VENT (OVERBOARD)
INLET
OUTLET (TO RESERVOIR)
VACUUM RELIEF
INLET
TO RESERVOIR
VENT

216.57

Figure 6-16.—Reservoir air pressure regulator.

the HANDPUMP FILL CONNECTION or the POWER FILL CONNECTION which are located on the hydraulic servicing panel. See fig. 6-17.

A reservoir fill selector valve, also located on the hydraulic service panel, is used to select the reservoir to be filled.

With the fill selector valve positioned to the No. 1 reservoir, hydraulic fluid enters the fill connection and passes through the fill line filter and the selector valve to the fill-pressure operated vent valve and the fill back pressure valve. See fig. 6-15. The fill back pressure valve prevents the fluid from entering the reservoir until the pressure operated vent valve is opened to dump the reservoir pressurization. When the fill line pressure reaches 15 to 30 psi, the pressure-operated vent valve opens and dumps the reservoir pressurization overboard. As the fill line pressure increases from 40 to 60 psi, the back pressure valve unseats and allows hydraulic fluid to enter the reservoir. When the hydraulic fluid in the reservoir reaches the full level, all additional fluid is dumped overboard through the fill-pressure operated vent valve to prevent overfilling. As the fill line pressure decreases below 40 psi, the back pressure valve will close. When the fill selector valve is returned to the OFF position, the fill pressure line is vented overboard permitting the pressure operated vent valve to close. With the vent valve closed, the reservoir can be pressurized.

Servicing of this reservoir may be accomplished with the Loe H250-1 shown in Chapter 11 (fig. 11-43) or the HSU-1 Fluid Service Unit shown in Chapter 11 (fig. 11-44).

To fill the reservoir with the check and fill stand, it is connected to the power fill connection on the hydraulic servicing panel shown in figure 6-17.

The reservoir fill selector valve handle is positioned to the No. 1 power system reservoir and an open container placed under the reservoir overboard drain.

Apply a pressure of 80 to 110 psi with a flow of no more than 1.5 gpm to the system until a continuous flow of fluid is discharged from the overboard drain.

Check the fluid level in the reservoir visually at the sight gage, or if electrical power is applied to the aircraft, by pressing the green normal-level light located on the servicing panel. This light should come on if the reservoir is properly serviced.

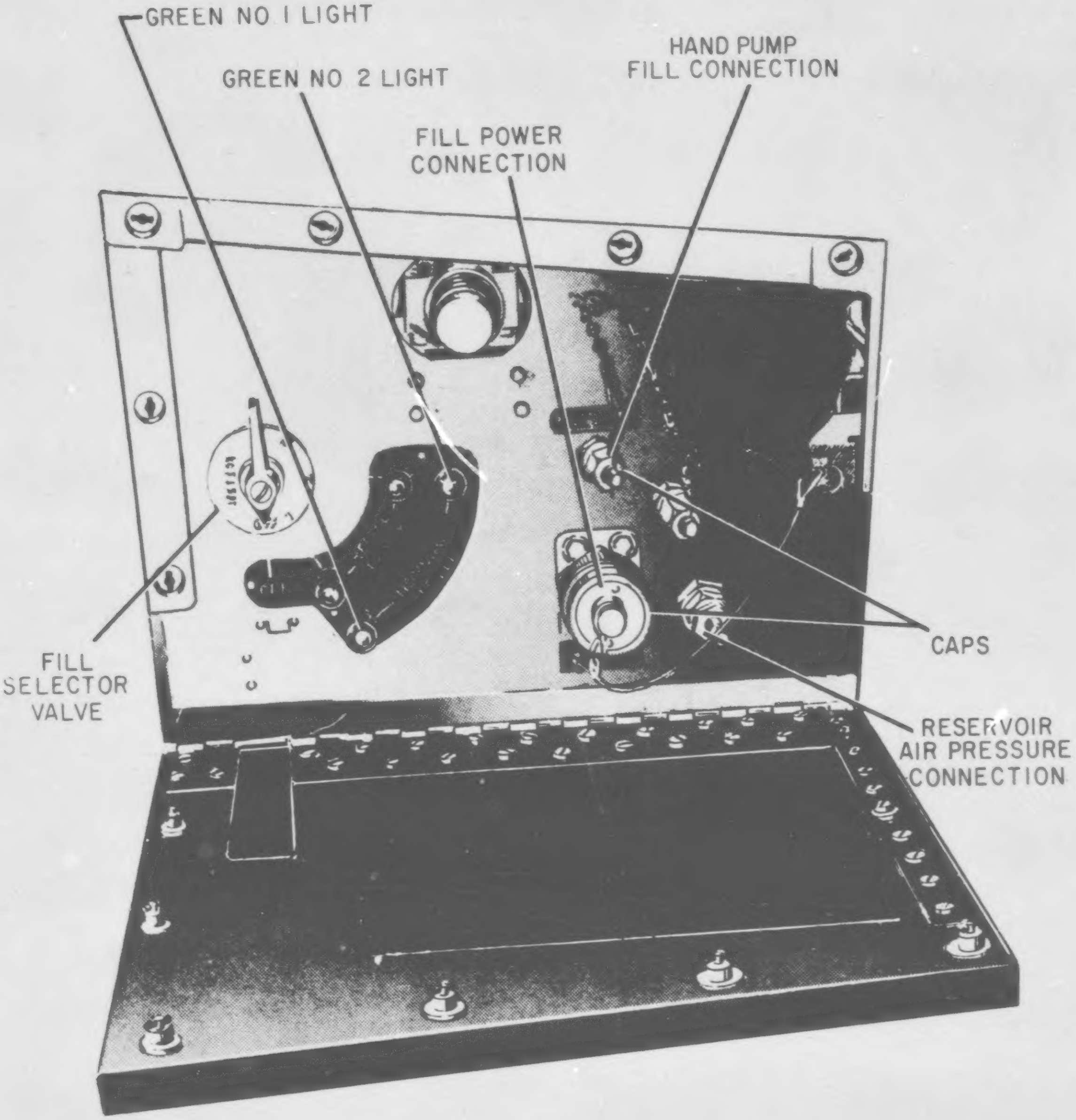
After ascertaining that the reservoir is properly filled, it should be repressurized by applying an external source of air pressure (60 to 110 psi) to the ground pressurization fitting on the hydraulic servicing panel. This is to ensure pressure on the hydraulic fluid when starting the engines.

MAINTENANCE.–Maintenance of this type reservoir and its air-pressurization components and filling components consists of servicing the system, parts removal and installation, and replacement of cure date seals and miscellaneous parts. The replacement of seals and parts should be accomplished at the intermediate level of maintenance so that the components may be properly bench-tested following repair.

Fluid-Pressurized Reservoir

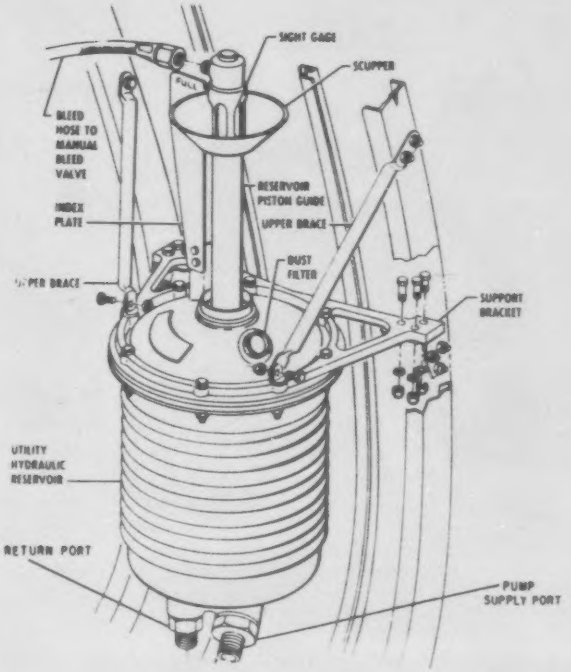
The reservoir shown in figure 6-18 is a fluid-pressurized reservoir. This reservoir consists of a tank which is formed by welding a dome to the lower end of a cylindrical shell and bolting a lid to a flange on the upper end. Protection against handling damage and high exterior temperatures is obtained by enclosing the tank in a perforated radiation shield of corrugated aluminum alloy. A dust filter, in the lid opposite the index plate, filters the air which is drawn into the upper (air) chamber as the fluid level changes. Ports are provided in the lower end of the dome to accommodate fittings for connecting the system supply, pressure, and return lines.

A stationary piston, containing an integral passage extending from its base to ports below its head, is installed vertically inside the tank. The passage through the piston is connected to the pressure line in the dome, the piston head is enclosed within the chamber of a sliding cylinder which has the lower end flared to form a diaphragm. A V-ring around the outer edge of


GREEN NO 1 LIGHT
GREEN NO 2 LIGHT
FILL POWER CONNECTION
HAND PUMP FILL CONNECTION
FILL SELECTOR VALVE
CAPS
RESERVOIR AIR PRESSURE CONNECTION

216.58

Figure 6-17.–Hydraulic servicing panel.



216.59

Figure 6-18.—Fluid-pressurized reservoir.

the diaphragm seats against the inner surface of the tank and provides an air and fluid separation. Thus, the reservoir is divided into two chambers—upper (air) and lower (fluid). See fig. 6-19.

Pressurization of the reservoir fluid supply is effected by system fluid pressure entering through the piston passage into the cylinder chamber and forcing the diaphragm down against the fluid supply.

The upper end of the cylinder extends through the lid and contains a sight gage with a guide which is used in conjunction with an index plate to reflect fluid level.

Fluid displaced by an actuating system operation forces the air trapped in the system to the lower (fluid) chamber of the reservoir. The air bubbles rise through an integral passage in the cylinder and collect in the reservoir sight gage. Air may be removed from the sight gage by pressing the manual bleed valve. (See fig. 6-19.)

The manual bleed valve provides a means for bleeding air from the reservoir. The valve, which is interconnected between the outlet port above the reservoir sight gage and an overboard bleed hose, is a pushbutton plunger type which is normally closed.

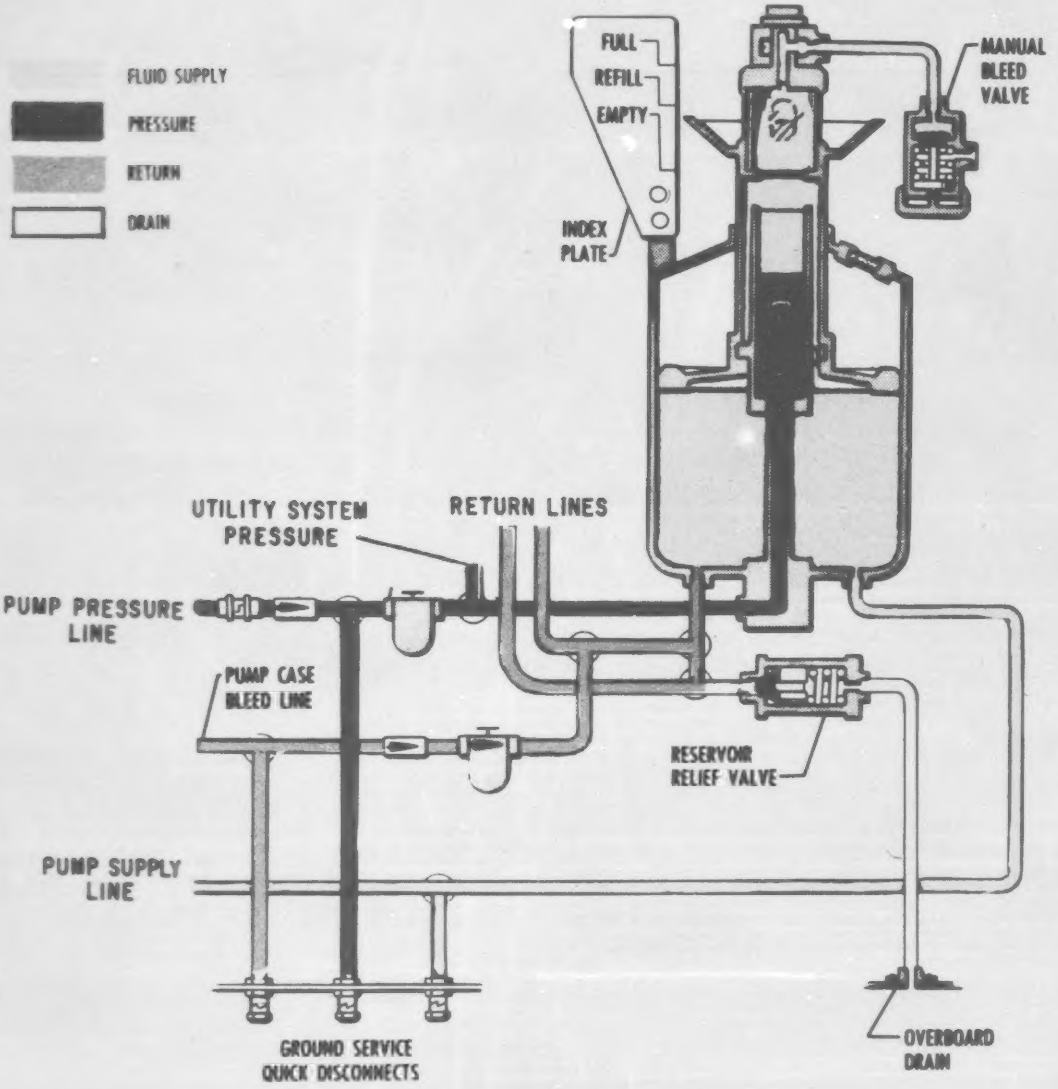
A reservoir relief valve (fig. 6-19) is provided to vent hydraulic fluid overboard if the pressure in the hydraulic reservoir should exceed 60 psi. The valve reseats when the pressure drops to approximately 50 psi. The valve is connected directly to the system return port cluster, which is located at the lower end of the reservoir. Excess fluid is vented through an overboard drain line.

MAINTENANCE.—Malfunction of this type reservoir requires replacement of the complete unit. Repair is normally accomplished at an intermediate or higher maintenance level.

Intermediate level repair of this reservoir involves a complete disassembly of the unit, cleaning, installation of new cure date kit parts, quality control inspection of parts and assembly, reassembly, lubrication, and bench functional testing of the unit for operation integrity. Repairs at this level are limited to replacement of cure date kit parts. If the unit does not function properly after replacement of these parts, and after testing is completed, the reservoir should be packaged and sent to supply.

NOTE: A cure date repair kit is a parts kit containing cure-dated items such as diaphragms, packings, and O-rings which are subject to age controls or shelf life limitations. This type repair parts kit may also contain soft goods not subject to age controls, such as gaskets and seals, plus metallic items such as screws, nuts, and washers. The cure date parts kit is prepared for various hydraulic components and is available to all maintenance levels as authorized.

FILLING.—Filling a fluid-pressurized reservoir, such as the A-4E utility system reservoir, is accomplished by connecting an external hydraulic power supply to the utility


FLUID SUPPLY
PRESSURE
RETURN
DRAIN
FULL
REFILL
EMPTY
INDEX PLATE
MANUAL BLEED VALVE
UTILITY SYSTEM PRESSURE
RETURN LINES
PUMP PRESSURE LINE
PUMP CASE BLEED LINE
RESERVOIR RELIEF VALVE
PUMP SUPPLY LINE
GROUND SERVICE QUICK DISCONNECTS
OVERBOARD DRAIN

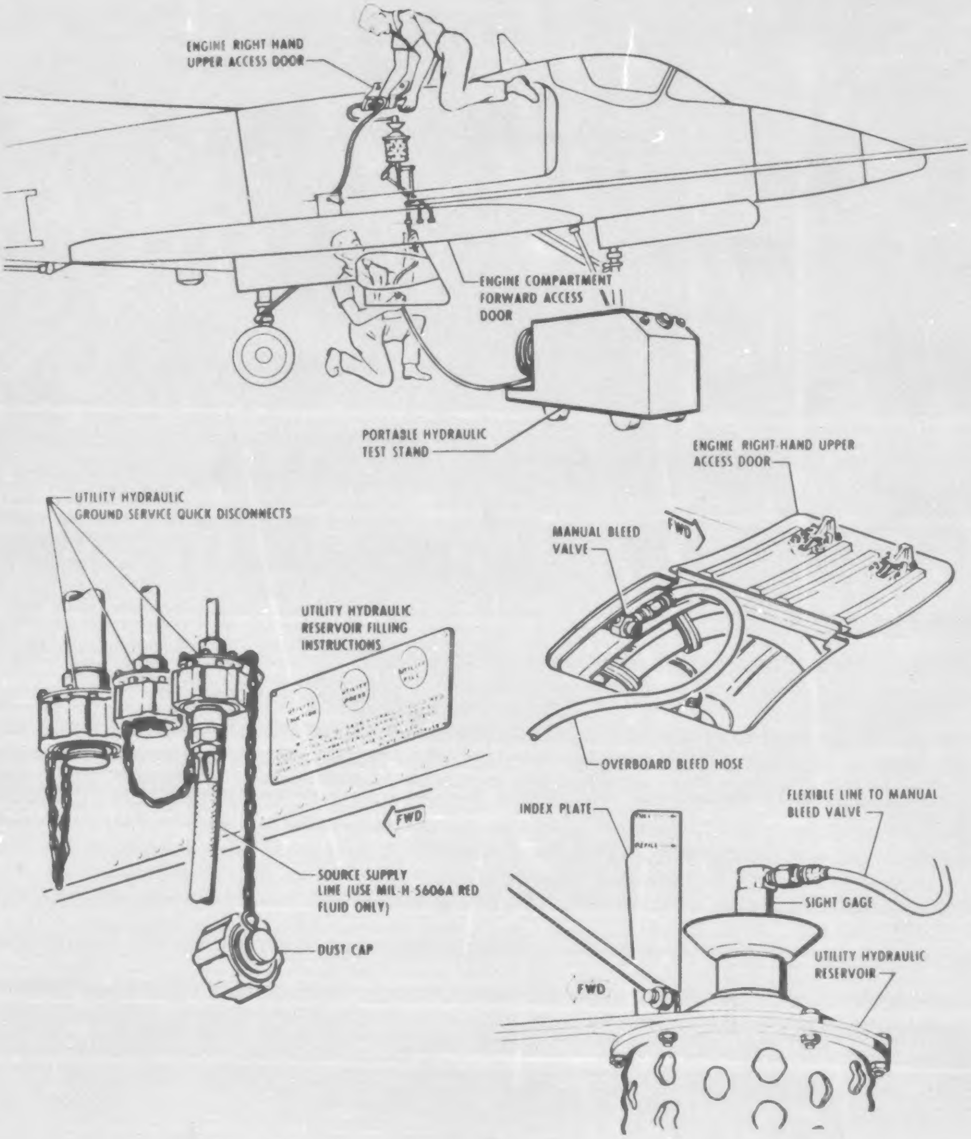
216.60

Figure 6-19.–Fluid-pressurized reservoir schematic.

hydraulic reservoir fill quick-disconnect as shown in figure 6-20.

Remove the bleed line from its retaining clips and place the free end of the hose in a suitable container to receive the overflow fluid when bleeding.

Apply pressure from the external power supply (not exceeding 65 psi) until the piston rises to the full line on the reservoir sight gage. Depress the manual bleed valve as the reservoir is being filled to free the air bubbles from the sight gage.


ENGINE RIGHT HAND UPPER ACCESS DOOR
ENGINE COMPARTMENT FORWARD ACCESS DOOR
PORTABLE HYDRAULIC TEST STAND
ENGINE RIGHT-HAND UPPER ACCESS DOOR
UTILITY HYDRAULIC GROUND SERVICE QUICK DISCONNECTS
MANUAL BLEED VALVE
FWD
UTILITY HYDRAULIC RESERVOIR FILLING INSTRUCTIONS
OVERBOARD BLEED HOSE
FWD
INDEX PLATE
FLEXIBLE LINE TO MANUAL BLEED VALVE
SOURCE SUPPLY LINE (USE MIL-H-5606A RED FLUID ONLY)
SIGHT GAGE
DUST CAP
UTILITY HYDRAULIC RESERVOIR
FWD

216.61

Figure 6-20.—Filling fluid-pressurized reservoir.

After the piston has reached the full level, disconnect the external power supply, reinstall the bleed line in its retaining clips, and wipe any spilled fluid from the surrounding area.

ACCUMULATORS

There are two general types of accumulators in use in naval aircraft. They are the spherical and the cylindrical. However, the cylindrical type, which has proven more satisfactory for use with the high pressure systems, is used in most installations.

The accumulator is used essentially for stowing energy to provide a supply of high-pressure fluid on demand. It also acts as a surge chamber or shock absorber for excessive loads which are imposed on the individual systems.

The cylindrical accumulator contains a free-floating piston (figure 6-21) which separates the air and hydraulic fluid chambers. The cylindrical accumulator consists of a barrel assembly, a piston assembly, and two end cap assemblies. The barrel assembly houses the piston and incorporates provisions for securing the end caps. The piston incorporates two packings. A drilled passage in the piston provides for lubrication of the seal on the air chamber end.

The end caps seal the open ends of the barrel and contain air and hydraulic fluid ports. This accumulator is usually mounted at the ends by means of two U-shaped brackets.

Some aircraft accumulators are heated by an electrical blanket around the outside. This heating blanket serves to maintain the accumulator pressure within an acceptable pressure range regardless of the surrounding (ambient) air temperature.

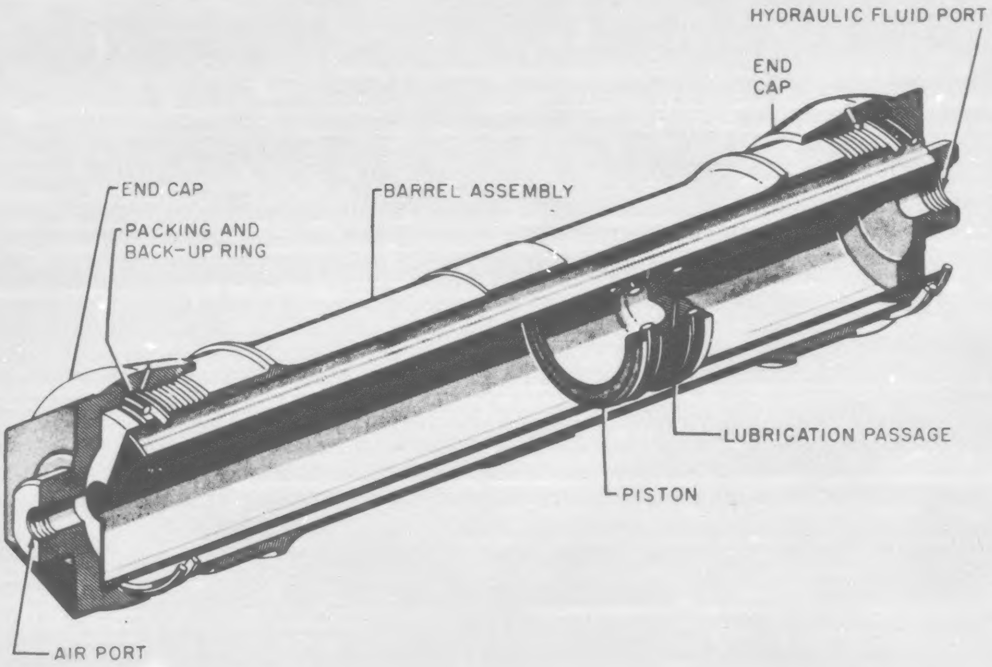


Figure 6-21.–Cylindrical accumulator.

The cylindrical accumulator should be inspected periodically for leakage, security of mounting, and proper air preload.

Air preload pressure is checked after exhausting all hydraulic pressure from the system. The air preload gage should indicate the pressure specified in the applicable Maintenance Instructions Manual. If the air preload is found to be low, the accumulator and the connections from the accumulator to the servicing panel or air charge valve should be inspected for leakage. External air leaks may be found by applying a soap solution to all connections and checking for air bubbles. Internal leakage may be checked by bleeding off the remaining air preload and removing the air charge valve. If hydraulic fluid is present in the air chamber, the accumulator should be removed and repaired or replaced as necessary.

Repair of the cylindrical type accumulator consists of disassembly, cleaning, inspection, replacement of all sealing devices, and reassembly.

After disassembly and cleaning, the interior of the barrel and the exterior of the piston should be inspected for excessive wear, scratches, burrs, or any other defect which would affect the free sliding action of the piston in the barrel.

When reassembling the cylindrical accumulator, a light coat of preservative oil or clean hydraulic fluid should be applied to all internal surfaces, threads, O-rings, and gaskets. This preservative oil acts as a lubricant for the sealing devices when installing the piston and end caps.

Before reinstalling a reworked accumulator, it should be bench tested in accordance with the applicable Maintenance Instructions Manual. When the accumulator has been reinstalled, the air preload should be replaced in accordance with the applicable Maintenance Instructions Manual.

NOTE: Only nitrogen or dry filtered air should be used to service an accumulator. When charging an accumulator, ensure that all system hydraulic pressure has been exhausted. Trapped hydraulic pressure in the system will give a faulty preload indication. When servicing some accumulators, it is necessary to bleed off the hydraulic pressure in the system as the preload air pressure is applied.

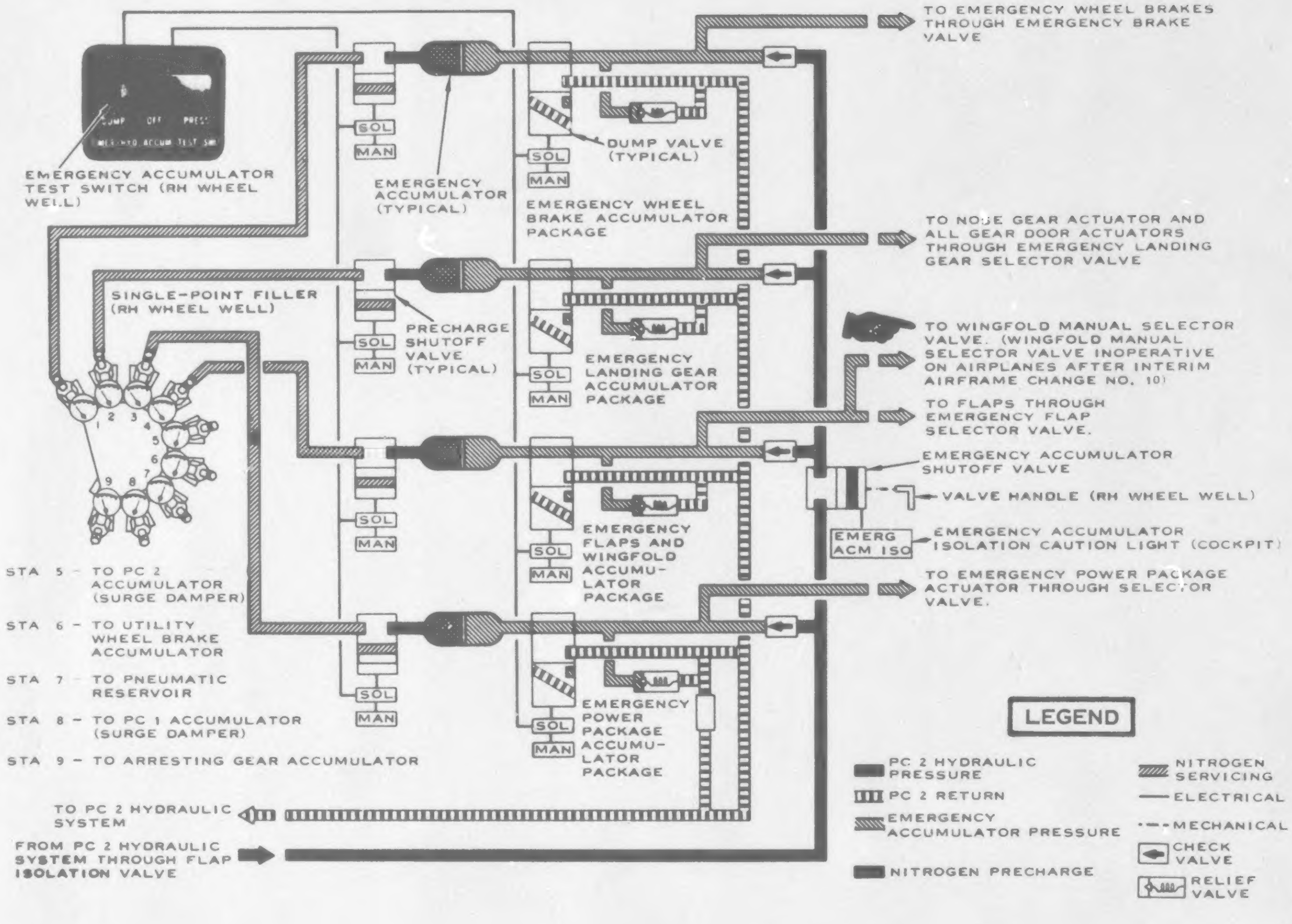
Accumulator Precharge System

The accumulator precharge system of the A-7 aircraft provides a more reasonable and modern approach to accumulator servicing than is found on most aircraft. This system provides a means of precharging, depressurizing, and pressure checking all aircraft accumulators and pneumatic reservoirs from a single location within the right-hand wheel well. Figure 6-22 provides a schematic of the system. The precharge system consists of the single point filler assembly and the emergency accumulator test switch. The single point filler assembly has nine high-pressure pneumatic gages and filler valves mounted on the common housing. Each valve and gage is identified by a station number which identifies it to the system accumulator it accommodates.

In order to charge, check the accumulator precharge pressure, or depressurize any one of the four (stations 1-4) emergency accumulators (fig. 6-22), it is necessary to control the accumulator package solenoid-operated valves with the emergency accumulator test switch. External electrical power is required to operate these valves.

As with a conventional accumulator system, before any of the four emergency accumulators can be checked or precharged, the hydraulic fluid must be dumped from the accumulator fluid side. This is accomplished by placing the emergency accumulator test switch on the DUMP positon. This connects power to the solenoid-operated shutoff valves in the hydraulic side of each of the four emergency accumulators and dumps hydraulic fluid into the return lines of the power control No. 2 supply system.

With the hydraulic fluid dumped, checking, charging, or bleeding the nitrogen pressure in the emergency accumulators is accomplished the same as for other stations with the exception that the emergency accumulator test switch must be held in the PRESS position. This opens the solenoid-operated shutoff valves on the nitrogen side of each of the four emergency accumulators, thus connecting the nitrogen side


TO EMERGENCY WHEEL BRAKES THROUGH EMERGENCY BRAKE VALVE
TO NOSE GEAR ACTUATOR AND ALL GEAR DOOR ACTUATORS THROUGH EMERGENCY LANDING GEAR SELECTOR VALVE
TO WINGFOLD MANUAL SELECTOR VALVE. (WINGFOLD MANUAL SELECTOR VALVE INOPERATIVE ON AIRPLANES AFTER INTERIM AIRFRAME CHANGE NO. 10)
TO FLAPS THROUGH EMERGENCY FLAP SELECTOR VALVE.
EMERGENCY ACCUMULATOR SHUTOFF VALVE
VALVE HANDLE (RH WHEEL WELL)
EMERG ACM ISO
EMERGENCY ACCUMULATOR ISOLATION CAUTION LIGHT (COCKPIT)
TO EMERGENCY POWER PACKAGE ACTUATOR THROUGH SELECTOR VALVE.
DUMP OFF PRESS
EMERG HYD ACCUM TEST SW
EMERGENCY ACCUMULATOR TEST SWITCH (RH WHEEL WELL)
EMERGENCY ACCUMULATOR (TYPICAL)
DUMP VALVE (TYPICAL)
EMERGENCY WHEEL BRAKE ACCUMULATOR PACKAGE
SOL
MAN
SINGLE-POINT FILLER (RH WHEEL WELL)
PRECHARGE SHUTOFF VALVE (TYPICAL)
EMERGENCY LANDING GEAR ACCUMULATOR PACKAGE
EMERGENCY FLAPS AND WINGFOLD ACCUMULATOR PACKAGE
EMERGENCY POWER PACKAGE ACCUMULATOR PACKAGE
1 2 3 4 5 6 7 8 9
STA 5 – TO PC 2 ACCUMULATOR (SURGE DAMPER)
STA 6 – TO UTILITY WHEEL BRAKE ACCUMULATOR
STA 7 – TO PNEUMATIC RESERVOIR
STA 8 – TO PC 1 ACCUMULATOR (SURGE DAMPER)
STA 9 – TO ARRESTING GEAR ACCUMULATOR
TO PC 2 HYDRAULIC SYSTEM
FROM PC 2 HYDRAULIC SYSTEM THROUGH FLAP ISOLATION VALVE
LEGEND
PC 2 HYDRAULIC PRESSURE
PC 2 RETURN
EMERGENCY ACCUMULATOR PRESSURE
NITROGEN PRECHARGE
NITROGEN SERVICING
ELECTRICAL
MECHANICAL
CHECK VALVE
RELIEF VALVE

216.63

Figure 6-22.—Emergency accumulator precharge—schematic.

of the accumulators directly to the high-pressure filler valves and gages of the single point filler assembly.

The hydraulic system pressure for stations 5, 6, 7, and 9 is depleted by cycling the applicable system's cockpit controls until all hydraulic pressure is relieved. Station 8 hydraulic pressure is relieved in the same manner as was utilized for stations 1-4. By holding the emergency accumulator test switch in DUMP for approximately 1 minute, all PC No. 1 accumulator pressure will be depleted. Prechargeing and checking of nitrogen pressure for stations 5 through 9 is accomplished by connecting an external source of nitrogen to the appropriate filler valve, opening the filler valve, and charging to the pressure specified in the Maintenance Instructions Manual. If the heater blanket for an accumulator has been ON, electrical power to the heater must remain off for at least 1 hour prior to checking the precharge.

FILTERS

A filter is a screening or straining device utilized to prevent particles and insoluble contaminants from entering the system in which it is installed. If such objectionable material is not filtered out of the system, it may cause catastrophic hydraulic system failure. The hydraulic fluid holds in suspension tiny particles that are generated during the normal wear of selector valves, pumps, and other system components. If not filtered out, they can damage parts within the many close tolerance components common to today's aircraft. It is apparent that the reliability and efficiency of the entire hydraulic system therefore depend upon adequate filtration of the fluid.

Filters may be located within the reservoir, in the pressure and return lines, or any other location where the designer of the system decides that they are needed to safeguard against contaminants.

There are many types of filters. Their position in the aircraft and design requirements determines their size and shape.

Most filters used in today's aircraft are of the inline type. The inline filter assembly is comprised of three basic units–head assembly, bowl, and element. The head assembly is that part which is secured to the aircraft structure and connecting lines. Within the head of the bypass filter assembly there is a bypass valve which routes the hydraulic fluid directly from the inlet to the outlet port if the filter element becomes clogged with foreign matter. The bowl is the housing which holds the filter element to the filter head and is that part which is removed whenever element replacement is required.

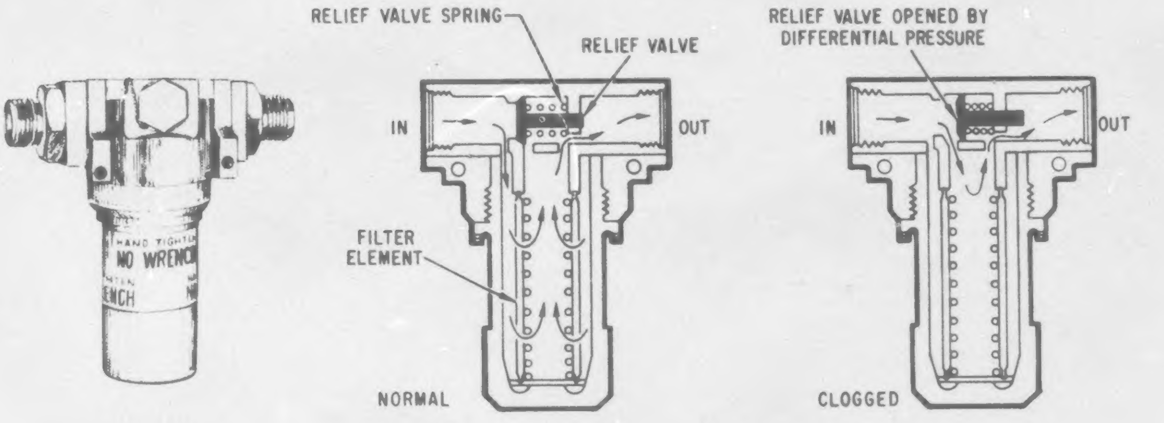
The element may be labeled as either a micronic, porous metal, woven mesh, or magnetic type. The term micronic has become associated with a specific filter with a filtering element made of a specially treated cellulose paper. The paper is formed in vertical convolutions (wrinkles) and arranged in a cylindrical pattern. A spring or support tube in the hollow core of the element holds the element in shape. Several aircraft manufacturers refer to the filters utilized in their aircraft as micronic due to the fact that they have a micron rating. In this respect the term micronic filter can be used to describe almost any filter element.

Most of the filter assemblies utilized in naval aircraft and associated ground support equipment are of the full flow design; that is, all the fluid which enters the unit passes through the filtering element. This provides a positive filterring action of all fluid within the system. Because of the resistance to flow caused by the filter element, especially when it becomes dirty, many filter assemblies incorporate a bypass valve which allows fluid to bypass the element when a specific pressure differential is reached.

Hydraulic fluid entering the filter assembly through the inlet port flows around the filter element inside the filter bowl. Filtering takes place as the fluid passes through the element and into the hollow core, leaving insoluble contaminants and particles on the outside of the element. Fluid continues to flow from the hollow core through the outlet port and into the system.

Micronic Type Filter (Disposable)

The representative micronic type disposable filter discussed earlier is shown in figure 6-23. This type filter is designed to remove 99 percent



215.49

Figure 6-23.—Micronic hydraulic filter.

of all particles 10 microns (0.000394) in diameter or larger. The filter assembly contains an integral pressure differential bypass valve that allows fluid to bypass the filter element when a predetermined pressure differential exists. The filter should be replaced with a new filter element at the interval specified in the Maintenance Instructions Manuals. Disposable filters are usually labeled as disposable on the bottom of the element.

Disposable 5-micron absolute filter elements have been recently produced that enable the user to obtain the full benefits of fine filtration without paying the penalty of excessive costs, size, and weight, and in some cases pressure drop. Many aircraft users are turning to this type filter in lieu of the reusable ones. The expense of cleaning equipment and the manhours expended in returning the filters to a reusable condition exceeds the cost of this new filter, and a higher degree of filter reliability is assured.

The most common filter medium is composed of organic and inorganic fibers integrally bonded with an epoxy resin. These fibers are faced on both sides by an aluminum alloy mesh for protection and added strength. Filters of this type may not be cleaned under any circumstances.

Another type of micron filter medium consists of a composite four-layer barrier. The main filtration is provided by a layer of very fine stainless steel fibers. These fibers are drawn in a random but controlled matrix which is processed to compress and bond the wires at their crossing points into a thin layer of filtration material with controlled filtration characteristics. Micron filters of this type are generally cleanable and reusable.

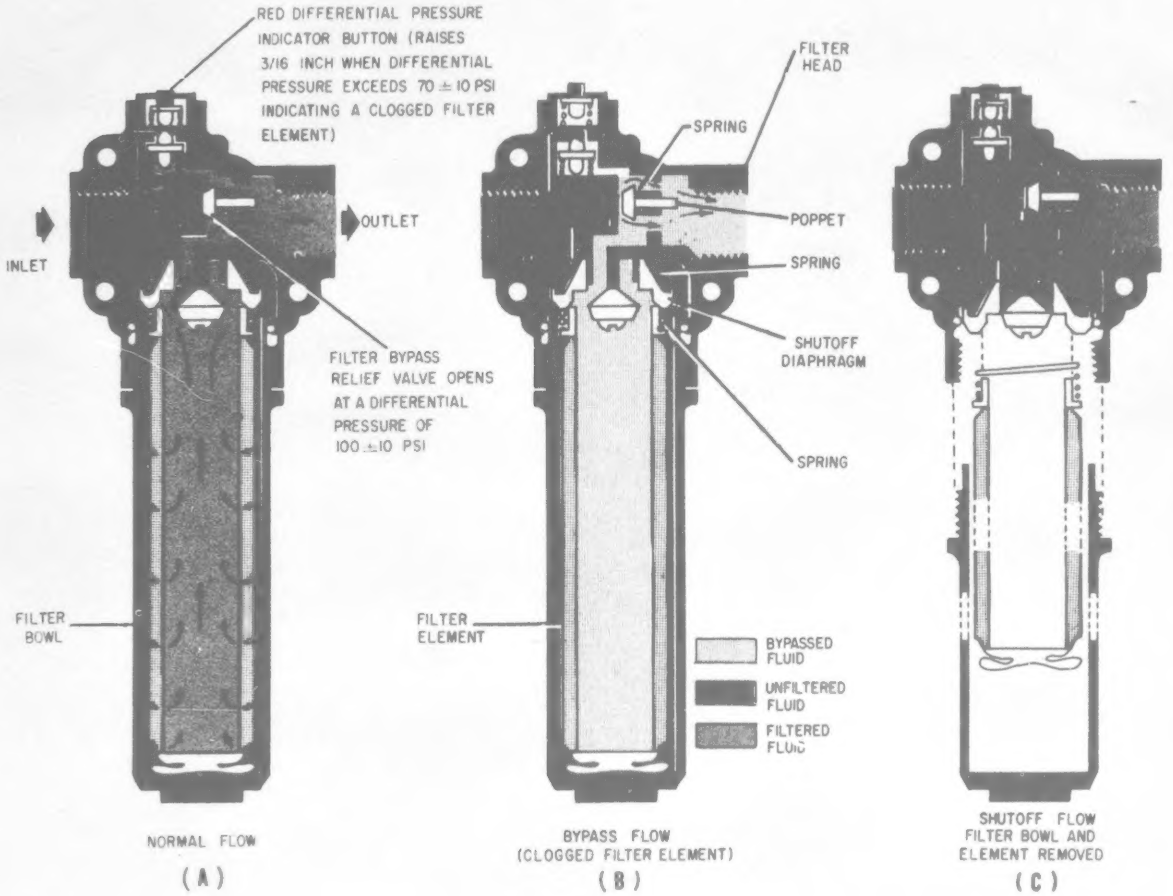
Stainless Steel Hydraulic Filter

Stainless steel filter elements are used in many aircraft. Chapter 11, fig. 11-45 illustrates a cross-sectional cutaway view of this type of filter. They are usually rated 15-, 25-micron, or larger absolute flow. They are designed to filter approximately 100 percent of the absolute particle rating. A description of this type of filter was provided earlier to provide a better understanding of filter element cleaning requirements. This type filter may be either the bypass type or the nonbypass type with a contamination differential pressure indicator.

On the bypass type, the pressure differential required to open the bypass will vary, depending on the installation. Usually the differential indicator will pop up at a predetermined pressure differential and come to the attention of maintenance personnel who perform the daily or preflight inspections. If the indicator is not observed and the filter element is not replaced, the differential pressure builds until it is high enough to unseat the bypass. Usually the contamination indicator is set to actuate at 20 to 30 psi below the pressure necessary to actuate the bypass valve.

On the nonbypass type the differential pressure indicator will pop at the specified differential pressure, but all fluid will continue to pass through the filter element until it becomes fully clogged. A low temperature lock out feature and, in some cases, a time delay feature are incorporated in some filter differential pressure indicators to prevent actuation below 20°F, thus eliminating false indications due to cold weather, pressure surges, or air in the system. The use of the nonbypass type filter assembly is essential to the proper operation of some hydraulic systems. The possibility of contaminated fluid passing the filter element and contaminating the entire system and damaging critical components is eliminated.

The filter assembly shown schematically in figure 6-24 is used on the A-6A. Inside the filter bowl is a permanent element through which solids larger than 15 microns cannot pass. If the


RED DIFFERENTIAL PRESSURE INDICATOR BUTTON (RAISES 3/16 INCH WHEN DIFFERENTIAL PRESSURE EXCEEDS 70 ± 10 PSI INDICATING A CLOGGED FILTER ELEMENT)
INLET
OUTLET
FILTER BYPASS RELIEF VALVE OPENS AT A DIFFERENTIAL PRESSURE OF 100 ± 10 PSI
FILTER BOWL
FILTER HEAD
SPRING
POPPET
SPRING
SHUTOFF DIAPHRAGM
SPRING
FILTER ELEMENT
BYPASSED FLUID
UNFILTERED FLUID
FILTERED FLUID

NORMAL FLOW
(A)

BYPASS FLOW
(CLOGGED FILTER ELEMENT)
(B)

SHUTOFF FLOW
FILTER BOWL AND
ELEMENT REMOVED
(C)

215.51.1

Figure 6-24.—Porous metal hydraulic filter assembly.

filter becomes clogged, the red differential pressure indicator button rises three-sixteenths inch above the filter head when the differential pressure exceeds 60 to 80 psi.

Under normal conditions (with a clean element), the spring-loaded button is magnetically held in the depressed position to a spring-loaded piston. (See view A, fig. 6-24.) Inlet pressure, acting against the top of the piston, is balanced against filter outlet pressure acting against the bottom of the piston. When the filter becomes clogged, the increase in inlet pressure forces the piston down against the spring, breaking the magnetic hold. (See view B, fig. 6-24.) When the magnetic hold is broken, the indicator button is forced up by its spring. When a differential pressure of 90 to 110 psi is built up, the spring-loaded relief valve opens and permits the fluid to bypass the clogged filter.

A shutoff diaphragm stops the fluid flow (when the system pressure is under 200 psi) through the ports when the filter bowl is removed. (See view C, fig. 6-24.) This eliminates fluid leakage when the bowl is removed to replace or clean the filter element.

After a clogged filter element has been replaced, the indicator button must be manually reset.

MAINTENANCE.–Maintenance of disposable type filters consists of replacing the filter element at the interval prescribed by the Maintenance Instructions Manual. Elements in filter assemblies equipped with a pressure differential indicator are not normally replaced until the indicator button is actuated. This decreases the possibility of system contamination from outside sources due to unnecessary handling. In all cases consult the MIM or Maintenance Requirements Card for the replacement interval.

Reusable type filters are cleaned by the ultrasonic method discussed earlier. They must pass a bubble point test following cleaning to ensure that they meet the filter test criteria established in the *Aircraft Hydraulics Manual,* NAVAIR 01-1A-17.

Certain porous metal type reusable filters that do not pass the bubble point test due to physical damage may be repaired. The damaged areas are marked with a red lead pencil (Venus Unique, Carmine Red-No. 1237 or equivalent) during the bubble point testing. Epoxy resin (Epon 828) conforming to Military Specification MIL-R-9300A and Diethylenetrimine catalyst are necessary to effect the repairs.

Mix the epoxy resin by measuring the required small quantity into a small container and adding the catalyst at a ratio of 10 to 12 parts of catalyst per 100 parts of resin. Mix thoroughly by stirring. The mixture must be used as soon as possible after mixing as the pot life is only 20 to 30 minutes. Apply a small diameter drop of resin/catalyst mixture to the center of the area being repaired using a toothpick or similar sharp pointed wooden instrument. Push the mixture into the pores of the wire mesh to ensure a satisfactory bond. Keep the area being bonded as small as possible. Place the element in an oven which is set at 140°F and cure for 30 minutes. Allow the element to cool to room temperature and subject it to boiling in 1, 1, 1 trichloroethane and ultrasonic cleaning. Test the repaired element to ensure that it meets the minimum bubble point test and flow test criteria. Discard any elements in which the total repaired area would exceed 3 percent of the filtration area.

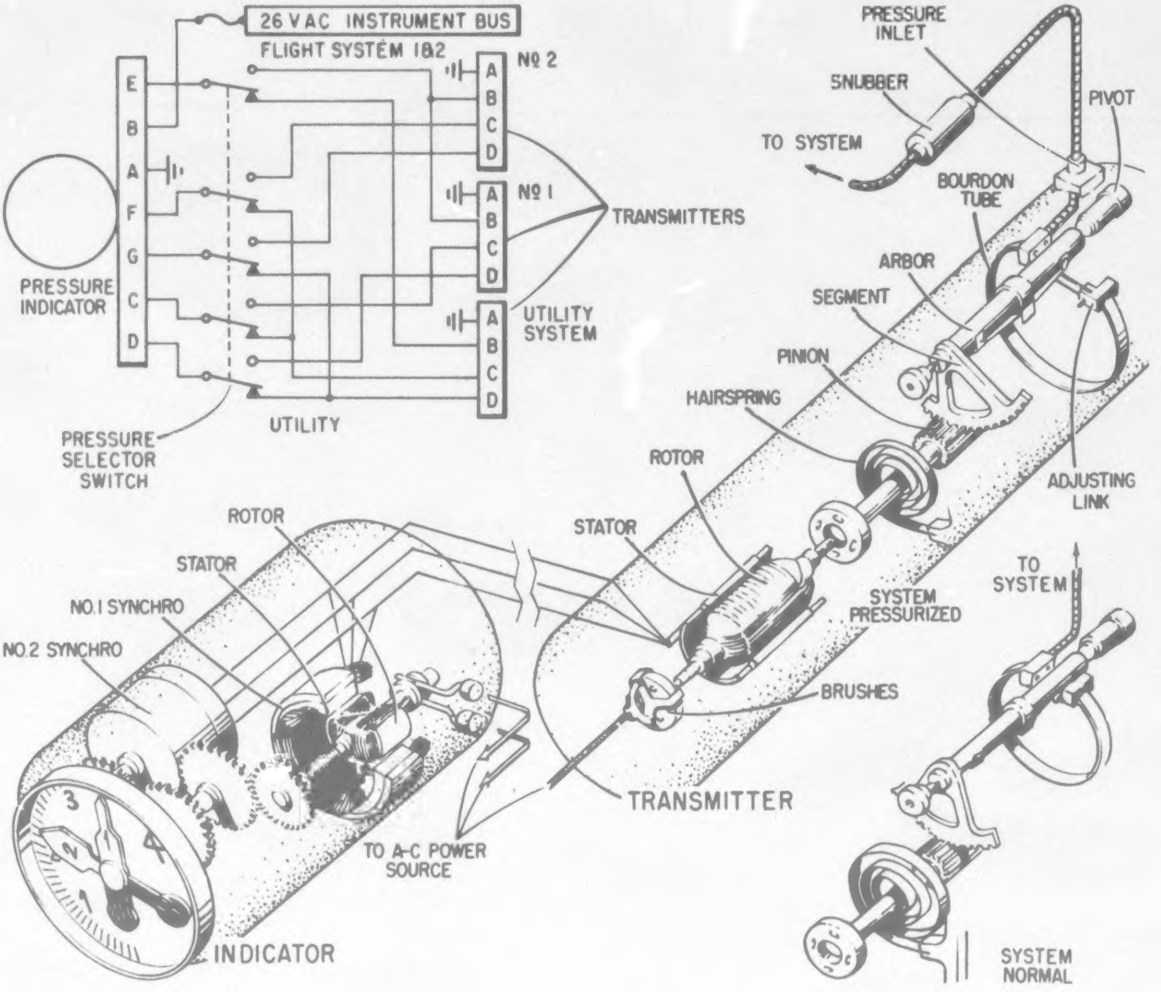
Filters removed from aircraft for cleaning and testing are placed in plastic bags and suitable containers that afford protection from contamination and damage and forwarded to the intermediate maintenance activity, utilizing an OPNAV 4790/36 Work Request.

Many intermediate maintenance hydraulic shops maintain a spare set of filters for each type of aircraft being supported. These filters are exchanged on a one-for-one basis so that supported activity's aircraft and equipment are not held in a DOWN status while filters are undergoing cleaning and testing.

PRESSURE INDICATING SYSTEMS

There are various methods of providing visual indications of hydraulic system pressure for the pilots' use. Two types commonly used are the direct pressure gage and the synchro (electric) type system.

The direct pressure gage is normally used to provide pressure indications for accumulators and arresting hook snubbers.


26 VAC INSTRUMENT BUS
FLIGHT SYSTEM 1&2
NO 2
NO 1
TRANSMITTERS
UTILITY SYSTEM
A
B
C
D
E
B
A
F
G
C
D
PRESSURE INDICATOR
PRESSURE SELECTOR SWITCH
UTILITY
PRESSURE INLET
SNUBBER
PIVOT
TO SYSTEM
BOURDON TUBE
ARBOR
SEGMENT
PINION
HAIRSPRING
ROTOR
ADJUSTING LINK
STATOR
TO SYSTEM
SYSTEM PRESSURIZED
BRUSHES
TRANSMITTER
ROTOR
STATOR
NO.1 SYNCHRO
NO.2 SYNCHRO
TO A-C POWER SOURCE
INDICATOR
SYSTEM NORMAL

216.64

Figure 6-25.—Hydraulic pressure indicating system.

Most aircraft hydraulic power systems utilize the synchro type system. The synchro system consists of a remote transmitter for each pump or system, a single or dual indicator, and a selector switch. The selector switch is installed in systems which incorporate three or more hydraulic power systems.

The hydraulic pressure indicator system for an aircraft which has a utility power system and two power control systems (fig. 6-25) consists of three remote transmitters, a selector switch, and a dual indicator. Each of the transmitters is connected to one of the three hydraulic systems. When the selector switch is in the flight control position, the dual pointers (marked 1 and 2) read their respective power control system pressure. When the switch is in the utility system position, both pointers align and indicate the utility pressure.

Each transmitter consists of a bourdon tube measuring device connected to a synchro. Movement of the bourdon tube under pressure causes the rotor of the synchro to rotate.

The indicator contains two synchros. The rotors of the indicator synchros are geared to separate pointers, the scale range of which is usually 0 to 4,000 psi. When ac power is applied to the pressure indicator system, the indicator rotors will be positioned electrically by the rotors in the transmitter synchros. When the selector switch is actuated to the utility position, both indicator synchros are connected in parallel to the utility system transmitter synchro. Whenever ac power is interrupted, the indicator pointers will remain fixed at the last pressure indication.

A pressure snubber is installed in the hydraulic pressure line (fig. 6-25) which connects the pressure transmitter to the hydraulic system. The pressure snubber consists of a body containing a small movable element. The element is a weight attached to a stem which slides in a close tolerance passageway.

The function of this unit is to prevent damage to the pressure transmitter by pressure surges and prevent pointer oscillation in the indicator due to pressure oscillations in the hydraulic power system. Surge damping is provided by the restricted passageway. Damping of oscillations is accomplished by the action of the weight. As the weight is moved, the movement of the stem aids in keeping the orifice clear of small particles.

NOTE: When installing a pressure snubber, ensure that the end marked GAGE is installed towards the pressure transmitter.

Maintenance

Maintenance of most pressure indication systems is the responsibility of personnel in the AE ratings. However, the AMH will have to troubleshoot the hydraulic power system to determine whether a high or low gage reading is a malfunction in the hydraulic pump or in the pressure indication system.

It is impossible to accurately check the hydraulic pump output using the electric pressure indication system gage because of the allowable tolerances in the pressure transmitter, pressure indicator, and the engine driven pump. For example, the E-1B hydraulic pump and pressure indicating system components have the following allowable tolerances:

Engine driven pump: + 80 to -150 psi for 1,500 psi.

Pressure transmitter: ±150 psi for 1,500 psi.

Pressure gage: ± 50 psi for 1,500 psi.

By accumulating the above tolerances, it is possible (with a pump pressure output of 1,500 psi) to obtain a maximum pressure gage reading of 1,780 psi, or a minimum pressure gage reading of 1,150 psi. Because of this condition, it is necessary to install a direct reading pressure gage in the pump pressure line to check the pump output.

RELIEF VALVES

A relief valve similar to the one illustrated in figure 6-26 is installed in all hydraulic power systems. The system relief valve prevents excessive pressure buildup in the system by dumping fluid into the return lines when an excessive pressure condition occurs. The relief valve shown in figure 6-26 is used on the A-6A, which has a 3,000-psi hydraulic power system.

The relief valve is installed between the pressure and return lines to allow excessive pressure to return to the reservoir. Fluid entering the inlet side of the valve flows around the poppet, and its pressure acts on the face of the piston. As fluid pressure increases above 3,000 psi, the piston moves against spring pressure. The poppet follows the piston, keeping the valve closed. At approximately 3,150 psi the poppet reaches the end of its travel, which is limited by the position of the adjusting nut. The relief valve is now open to relieve pressure to the return lines. This piston continues to move forward until full relief flow is reached at 3,560 psi. When the fluid pressure decreases to 3,100 psi, the compressed spring returns the piston to reseat (with the poppet), thereby closing the valve.

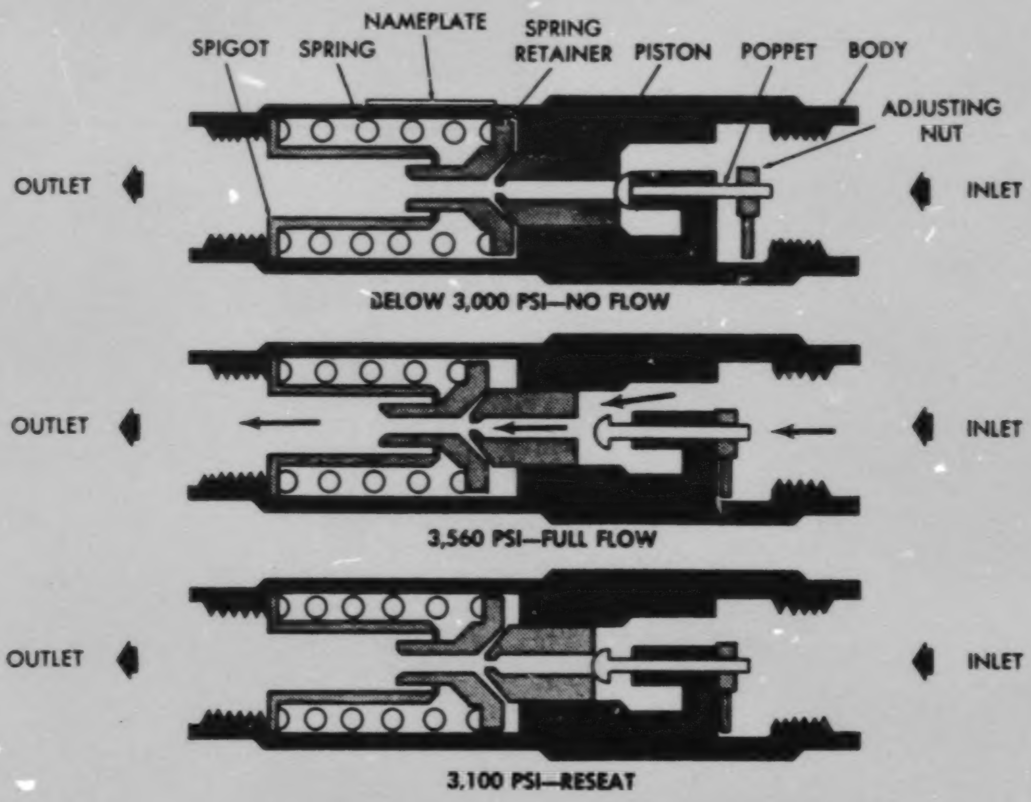

NAMEPLATE
SPIGOT
SPRING
SPRING RETAINER
PISTON
POPPET
BODY
ADJUSTING NUT
OUTLET
INLET
BELOW 3,000 PSI—NO FLOW
OUTLET
INLET
3,560 PSI—FULL FLOW
OUTLET
INLET
3,100 PSI—RESEAT
216.66

Figure 6-26.—System relief valve schematic.

Maintenance

Relief valve maintenance is limited to removal and installation, adjustment, and checking for leakage. When it is suspected that a relief valve is leaking internally, a flexible hose may be connected to the return port and the leaking fluid (if any) may be caught in a container. The reseat pressure may also be checked in this manner if an external power source is used.

NOTE: A leaking power system relief valve should be replaced.

CAUTION: Do not attempt any adjustment of the main relief valve while it is installed in the aircraft. The valve must be removed and adjusted on a hydraulic test stand.

SHUTOFF BYPASS VALVES

Several naval aircraft have shutoff valves installed in the supply line between the reservoir and the engine driven pumps. These valves are designed to be used in the event of an engine fire or a failure in the pump pressure line where the spraying of an atomized mist of hydraulic fluid would present a potential hazard. The gate or slide type valve utilized for this purpose on the E-2A is discussed in chapter 6 of the *AMH 3 & 2 Rate Training Manual.* At least one model aircraft uses a shutoff bypass valve for multiple reasons. The T-39 utilizes one shutoff bypass valve in conjunction with each engine-driven pump. Each valve is a two-position, three-port solenoid-operated valve. They are located in the pump supply line.

The primary purpose of the valve is to remove the torque loading of the hydraulic pump on the engine during ground or air engine starting. The valve positions are open (used in normal system operation) and shutoff or bypass (used for engine start, when the fire extinguisher system is operated, or when the engine is shut down in flight). The valve has a solenoid-controlled pilot valve, a spring-loaded valve spool, and a switch and actuating plunger.

When the pilot valve is energized, it ensures that the valve spool is in the bypass position. The pilot valve solenoid is energized when there is electrical power on the aircraft and the engine master switches are at OFF, or when the engine master switches are at ON and the ground or air start switches are at ON. The pilot valve is also energized to the bypass position when the fire extinguisher system handle is pulled. The valve spool is spring-loaded to the bypass position. The small end of the valve spool is open to system reservoir pressure.

The center of the valve is ported to pump outlet pressure. Because of the difference in diameters of the spool ends, any system pressure causes the valve spool to move towards the open position. When the engine is being started, the valve is energized to the bypass position, removing the load imposed on the pump. When the starter switch is released, the valve is deenergized but remains in the bypass position until sufficient fluid flow or output from the pump is produced to open the valve.

When the valve is open, hydraulic fluid from the reservoir supplies the hydraulic pump inlet. When the valve is in the shutoff or bypass position, reservoir fluid is cut off. The hydraulic pump output bypasses the hydraulic system through the shutoff bypass valve and is directed back to the pump inlet, creating a continuous bypass circuit. This action continues until the valve is deenergized and pressure is sufficient to open the valve. The actuating plunger of the valve operates internal switch contacts which illuminate the cockpit HYD SHUTOFF FAIL caution light if the valve fails to move to the bypass position. When this occurs, the pilot is warned against attempting an engine start until the malfunction can be checked.

This valve is unlike the firewall shutoff valve of the E-2A and some other aircraft which, when actuated to the shutoff position, starves the pump fluid supply. By continuously circulating the fluid from the pump outlet to the pump inlet, damage to the pump is avoided, yet pressure to the system can be avoided when necessary.

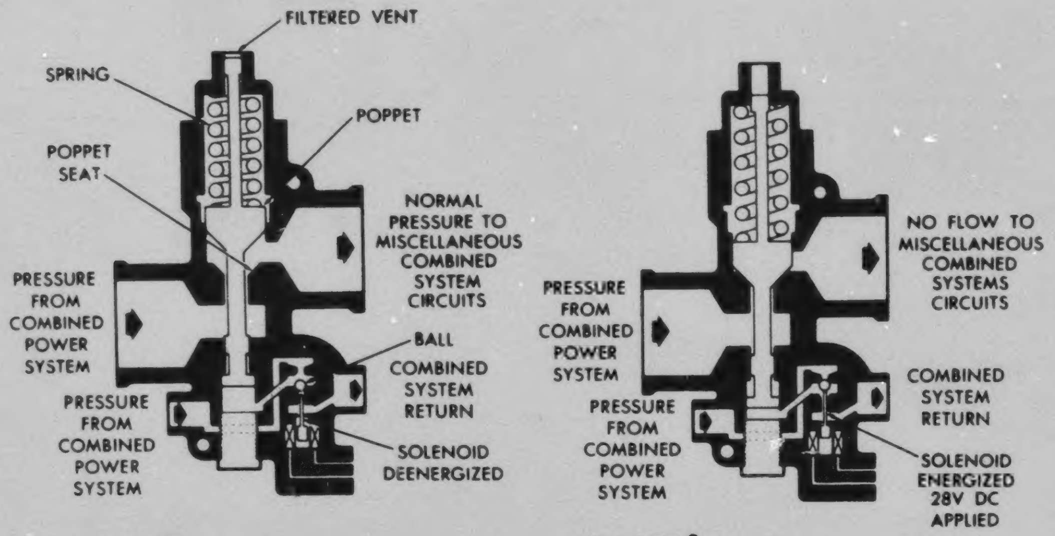
ISOLATION VALVES

Solenoid-operated isolation valves similar to the one illustrated in figure 6-27 are utilized in many aircraft systems. The valve controls fluid flow to the general utility systems not required during flight, such as the landing gear, brakes, wing fold, arresting hook, etc. The isolation valve is electrically controlled by a manually actuated switch in the cockpit. On some aircraft, like the A-6A, the switch is mounted next to the landing gear control handle; and when the landing gear handle is moved to the DOWN position, a peg on the handle causes the isolation valve switch to be returned to the deenergized position.

When the aircraft is airborne and there is no further use anticipated for the utility systems affected by the isolation valve the pilot may select the FLIGHT position on the isolation valve switch. This energizes the valve and shuts off hydraulic pressure to these systems that are not essential to flight. Returning the switch to the LDG position restores pressure to these systems.

The isolation valve in figure 6-27 functions under two conditions. In condition 1, the flight and combined systems are both supplying 3,000 psi, and the solenoid is deenergized. Combined system flow is through the valve. Pressure applied through the orifice above the ball to the bottom of the spring-loaded poppet opens the valve and allows combined system pressure to the secondary circuits mentioned above.

In condition 2, combined system pressure is still normal, but the isolation valve switch is at the FLIGHT position. The solenoid is energized and seats the ball in the orifice. This action


FILTERED VENT
SPRING
POPPET
POPPET SEAT
NORMAL PRESSURE TO MISCELLANEOUS COMBINED SYSTEM CIRCUITS
PRESSURE FROM COMBINED POWER SYSTEM
BALL
COMBINED SYSTEM RETURN
PRESSURE FROM COMBINED POWER SYSTEM
SOLENOID DEENERGIZED
NO FLOW TO MISCELLANEOUS COMBINED SYSTEMS CIRCUITS
PRESSURE FROM COMBINED POWER SYSTEM
COMBINED SYSTEM RETURN
PRESSURE FROM COMBINED POWER SYSTEM
SOLENOID ENERGIZED 28V DC APPLIED

CONDITION 1
Combined system pressure normal. Solenoid deenergized (isolation valve switch in LDG position) Normal flow to miscellaneous circuits.

CONDITION 2
Combined system pressure normal.
Solenoid energized (isolation valve switch in FLT position) No flow to miscellaneous circuits.

216.67

Figure 6-27.—Isolation valve (E-2A).

removes pressure from the bottom of the poppet, and spring action closes the valve. Combined system flow to the secondary circuits ceases, and full combined system output is available to the primary or essential flight control circuits. If the flight hydraulic power system pressure is lost, a manifold pressure-operated shutoff valve closes and no fluid is directed to the isolation valve. In this case, some of the secondary systems would have to be actuated by emergency or auxiliary means (landing gear and arresting gear), and combined system pressure would be available to the primary flight controls.

PRESSURE BALANCED EXTENSION UNITS

Pressure balanced extension units similar to the one illustrated in figure 6-28 are used to transfer fluid pressure from a fixed point to a movable point in the place of flexible hose. Each unit is a pressure balanced extension tube, consisting of a body containing a tube and a piston rod with a swivel joint at each end. The swivel joints can rotate 360 degrees around the lateral axis of the unit to allow rotary motion. They are capable of permitting ±10 degrees misalignment in either direction of the lateral axis. The pressure balanced feature results in friction being the only force which must be overcome in extending or retracting the unit. The tube and barrel are connected together as a unit with the piston rod sliding in and out. With fluid in the unit, pressure applied on area A (fig. 6-28) of the tube and piston rod tends to force the piston rod and barrel apart. Pressure on area B of the piston rod and barrel tends to force them together, resulting in a balancing of the pressure exerted on area A. Presently, the balanced pressure extension unit is primarily utilized on A-7 aircraft.

When installing a pressure balanced extension unit, ensure that the weep hole is placed on the bottom to allow for proper drainage, which is essential to proper operation.

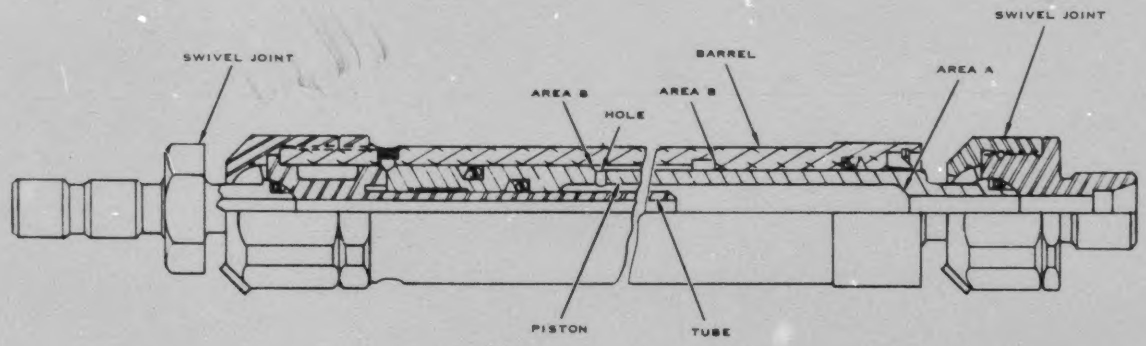


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Figure 6-28.–Pressure balanced extension unit.

MANIFOLDS

Manifolds are used in many hydraulic systems to provide a means whereby common fluid lines may come together and be distributed to other subsystems. Their design is such that they conserve space in the aircraft and permit ease of unit removal and replacement. Figure 6-29 illustrates the utility system manifold from the F-4B. This manifold directs filtered fluid under pressure to the various utility hydraulic systems and directs return fluid back to the reservoir.

The manifold incorporates a relief valve, three check valves, two quick disconnects, and three filters. Utility system pressure is directed into port A through the filter and out ports E and G. High pressure in the system is relieved by the integral relief valve. Return fluid enters through ports B and C and through the respective filters and is then directed to port H for a common return to the reservoir. Port D is provided as an external hydraulic pressure connection, and port F is a reservoir servicing connection. In each case, fluid entering and leaving the manifold is passed through a filter as a deterrent to fluid contamination.

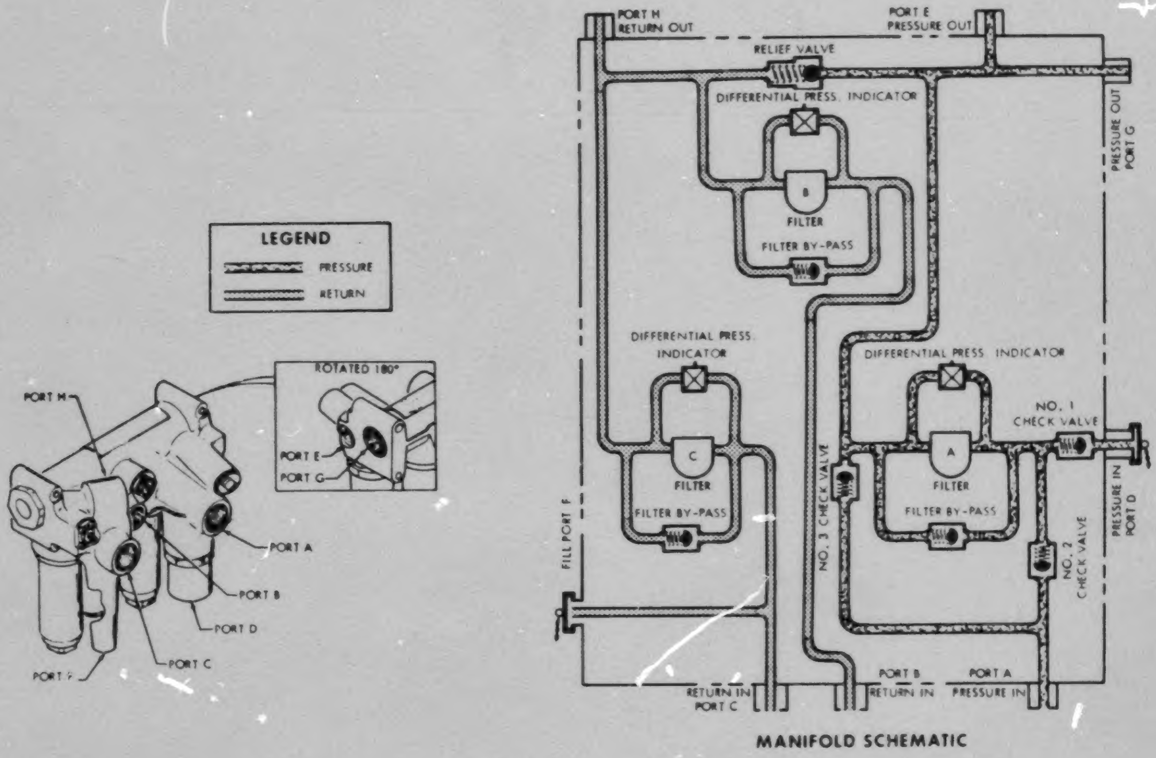
The manifold pressure differential indicators for each filter are equipped with 1-second time delays to prevent their actuation which could be caused by trapped air or pressure surges rather than a pressure differential caused by a clogged filter.

The manifold is designed so that any valve may be removed without disturbing any other part of the assembly.

Figure 6-30 illustrates a representative selector valve manifold assembly. The manifold can be designed to accommodate any number of selector valves and is supplied with pressure and return ports common to all the attached valves. A check valve is installed in the return passage for each valve. The bleed plug on the bottom of the manifold provides a convenient means of bleeding or draining the system.

The individual selector valves may be removed from the manifold and repaired at the intermediate level of maintenance. Intermediate maintenance on the manifold body consists of disassembling the body from the selector valves, cleaning, nondestructive inspection using whatever method specified in the MIM, replacement of any defective parts, reassembly, and testing.

The testing pressure for the return side is less than that for the pressure side. The burst pressure for the return side of the manifold shown in figure 6-30 is 2,500 psi. The test pressure for the pressure side is 4,500 psi. Exercise extreme caution when connecting the manifold to the test stand, ensuring that return side pressure does not exceed 1,500 psi. In all cases the step-by-step procedures provided in the Maintenance Instructions Manual or the applicable 03 Overhaul Manual must be adhered to.


LEGEND
PRESSURE
RETURN
ROTATED 180°
PORT E
PORT G
PORT H
PORT A
PORT B
PORT D
PORT C
PORT F
PORT H
RETURN OUT
PORT E
PRESSURE OUT
RELIEF VALVE
DIFFERENTIAL PRESS. INDICATOR
B
FILTER
FILTER BY-PASS
PRESSURE OUT
PORT G
DIFFERENTIAL PRESS.
INDICATOR
DIFFERENTIAL PRESS. INDICATOR
NO. 1
CHECK VALVE
C
FILTER
FILTER BY-PASS
A
FILTER
FILTER BY-PASS
FILL PORT F
NO. 3 CHECK VALVE
NO. 2
CHECK VALVE
PRESSURE IN
PORT D
RETURN IN
PORT C
PORT B
RETURN IN
PORT A
PRESSURE IN
MANIFOLD SCHEMATIC

216.69

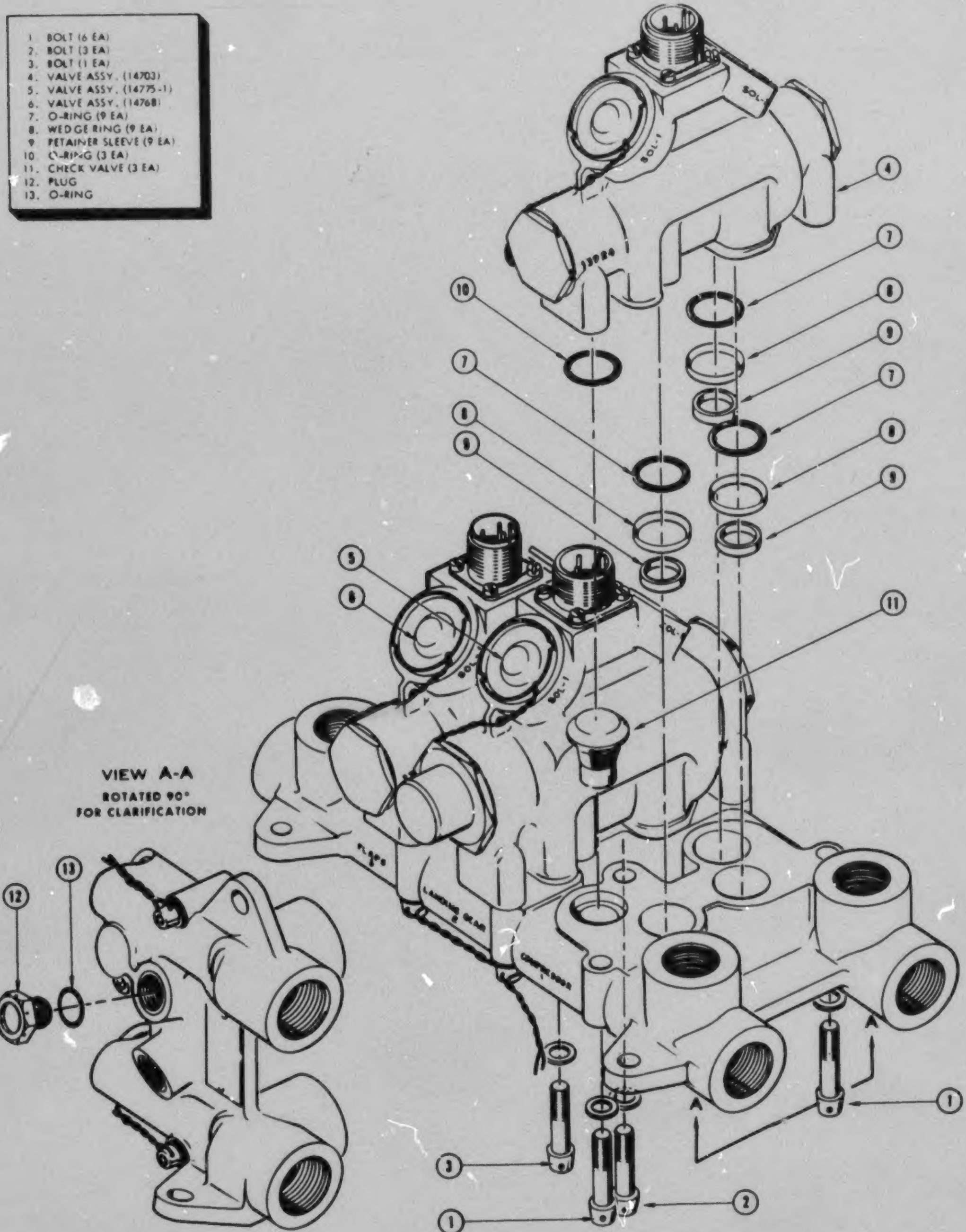
Figure 6-29.—System manifold—filter type.

SURGE SUPRESSORS

Hydraulic fluid flowing through a closed system is subjected to pressure pulses. The aircraft's hydraulic pumps cause the fluid to move through such a system in a series of pulsations. The pumps tend to chop the fluid into small quantities and emit it in pulses as it is forced into the hydraulic system. Instead of the fluid moving as one continuous stream, it moves with a rippling motion. The designer of the hydraulic system must take this into consideration, or these ripples can shake the system until it could fail from fatigue.

The opening and closing of valves or the actions of actuators in the system suddenly cause the fluid to stop or change direction. This sudden change causes hydraulic shock. For example, when fluid is suddenly stopped by the metal surface of a valve closing, the fluid upstream is still moving and piles up on the stopped fluid. This creates a rapid increase in pressure in the area immediately adjacent to the valve face. This increase is momentary and bleeds off to normal as soon as the column of fluid in the tubing is compressed by the sudden stop. However, it also causes a pressure pulse to bounce back through the entire upstream column.

This pulse is modified by the system plumbing, such as changes in tubing size, intersections, flexible hoses, etc. These surges or pressure waves are therefore reflected within the system and can actually reinforce each other to produce very high-pressure surges. The more extreme surges can be held to a minimum by substituting flexible hose for a section of rigid


1. BOLT (6 EA)
2. BOLT (3 EA)
3. BOLT (1 EA)
4. VALVE ASSY. (14703)
5. VALVE ASSY. (14775-1)
6. VALVE ASSY. (14768)
7. O-RING (9 EA)
8. WEDGE RING (9 EA)
9. RETAINER SLEEVE (9 EA)
10. O-RING (3 EA)
11. CHECK VALVE (3 EA)
12. PLUG
13. O-RING
VIEW A-A
ROTATED 90°
FOR CLARIFICATION
A
A
SOL-1
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
⑫
⑬

216.70

Figure 6-30.–Selector valve manifold assembly.

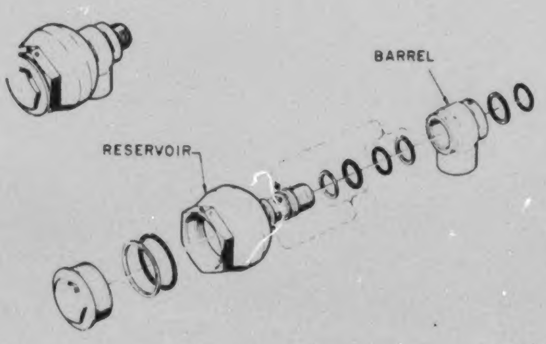
tubing, allowing the hose to flex and dampen the pulsations.

When a valve is suddenly opened, not all the fluid will start moving at once. Fluid from the pump and the upstream side of the valve overtakes the slightly lower pressure fluid downstream. When the two pressures meet, the pressure builds up and a shock wave occurs in much the same manner as when the valve was closed. The faster a valve opens or closes the higher pressure buildup and the more severe the shock wave. Hydraulic system designers utilize several devices to negate these surges.

Surge suppressing devices are common throughout aircraft hydraulic systems. Systems with accumulators usually utilize the normal action of the accumulator to absorb system shocks. Normally, a surge damper accumulator will be placed between the pump and the selector valves. If the accumulator was placed between the valve and the actuator, it would cause sluggish action from the actuator.

Surge accumulators in high volume systems are normally charged with nitrogen or air, with a diaphragm or piston separating the fluid from the air. Since the nitrogen or air is compressible, this dampens the surge and smooths out the system. If the accumulator is overcharged, the dampening will not be as effective as the designer planned and the system will take unnecessary punishment. If the accumulator is undercharged or pressure leaks out, there is no dampening effect and the system will be subjected to full pressure surges which could result in blown seals, bursted tubing, jammed parts, etc.

The surge suppressor illustrated in figure 6-31 is used in the F-4 aircraft and is representative of those installed in low volume systems. These suppressors are installed in each pump pressure line and function to reduce the pump pulsation pressure peaks. These would otherwise tend to cause resonating pressure surges common to low volume systems. The fluid enters the suppressor reservoir through the barrel fitting and the fluid in the reservoir tends to smooth out the surge before it is transmitted to the system. The suppressor also protects the pump from system-caused surges that rebound from the action of actuators changing direction and selector valves opening and closing.



216.71

Figure 6-31.—Hydraulic surge suppressor.

MAINTENANCE

Maintenance of the various hydraulic system components at the organizational level of maintenance is generally limited to troubleshooting, removal, and installation. Cure date seal and miscellaneous parts replacement is authorized at the intermediate level of maintenance on most items. Many components undergoing cure date seal replacement and/or miscellaneous parts replacement will require inspection of certain parts using one of the nondestructive methods of inspection discussed in chapter 5 and/or the use of other shop equipment such as the HCT-10 stationary test stand to accomplish repair and testing to certify proper operation and integrity of the component. Most Maintenance Instructions Manuals now feature an Intermediate Level Repair section for those components that may be repaired at the intemediate level of maintenance. In many cases, the depth of repair is limited to partial disassembly. In any case, the instructions provided in the Maintenance Instructions Manual or the 03 Overhaul Manual should be complied with to ensure that repair is accomplished correctly and that the component is operationally safe for reinstallation on the aircraft.

EMERGENCY POWER SYSTEMS

According to the Military Specifications which establish the requirements for aircraft hydraulic systems, all hydraulically operated systems considered essential to flight safety or landing must have provisions for emergency actuation. The specification further states that these emergency systems may utilize hydraulic fluid, compressed gas, direct mechanical linkage, or gravity for their actuation.

Some aircraft utilize mechanical linkage or gravity in conjunction with pneumatic pressure for emergency actuation of landing gear and other actuating systems where limited actuation is required. Most other essential hydraulically operated systems have emergency power systems which are powered by a hand pump, electric motor-driven pump, ram-air-turbine-driven pump, or a pneumatic compressor.

On some aircraft, such as the A-6, the hand pump is a part of the auxiliary hydraulic system and is not considered as part of the emergency power systems. It is utilized for ground operation of the canopy, extensible electronics platform, nose radome opening, and to recharge the brake accumulator. On the A-6, these systems may be operated utilizing aircraft system pressure or, if the aircraft is shutdown, they may be powered by the auxiliary electric motor-driven hydraulic pump or the hand pump.

HAND PUMP POWER SYSTEM

The hand pump emergency power system is used on a few low performance aircraft. This simple hydraulic power system usually consists of a hand-actuated pump, a filter, a reservoir, and a pressure relief valve.

Movement of the emergency pump handle causes the pump to draw hydraulic fluid from the emergency system reservoir and to deliver it under pressure through the emergency system filter to the emergency selector valves. In the event that none of the emergency selector valves has been actuated, or if the emergency actuating system pressure limits have been reached, the emergency system relief valve ports the excessive fluid to return. A check valve adjacent to each emergency selector valve prevents backflow of the fluid to the pump and permits hydraulic pressure to be built up in the selected emergency actuating system.

Hand Pump

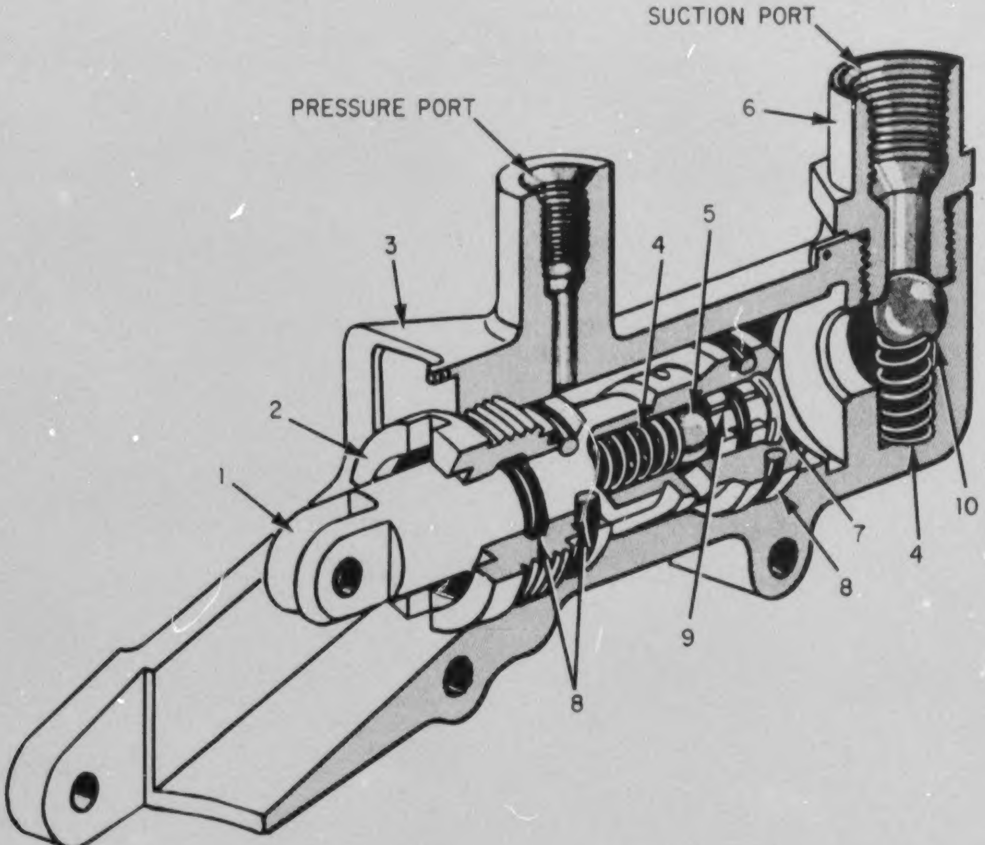
Hand pumps are either double action or single action types. The double action type delivers fluid on both the fore and aft strokes. See fig. 6-32. As the piston (1) is moved aft, fluid is drawn from the emergency reservoir past the ball check (10) into the pump chamber, and fluid held ahead of the piston (by the piston ball check), is expelled through the pressure port. As the piston is moved forward, the ball check at the suction port closes and the fluid in the chamber is forced past the piston ball check (5) and out the pressure port. This pump delivers approximately 1.304 cu. in. of fluid per pump cycle.

MAINTENANCE.–Maintenance of the hydraulic hand pump consists of operational checks, removal and installation, and repair. An operational check of the hydraulic hand pump is performed by installing a direct reading pressure gage in the pump pressure line and actuating one of the emergency actuating systems. With pressure built up in the pump pressure line, observe the pump shaft for piston creep, which (if present) indicates that the pump should be removed for repair or replacement.

If the testing shows that the pump piston creeps with a drop in pressure, the piston check ball and seat should be replaced and the pump reassembled with new O-ring packings. If the testing shows that pump pressure drops without piston creep, both check balls and seats should be replaced and the pump reassembled with new O-ring packings.

The hydraulic hand pump should be bench-tested as follows after completing repairs:

1. Connect the pump suction port to a supply of clean hydraulic fluid.
2. Connect a direct reading 3,000 psi pressure gage to the pump pressure port.
3. Actuate the pump piston until 2,500 psi is reached and observe the position of the piston for a sufficient length of time to establish a rate of creep. Maximum allowable rate of creep is 0.040 inch per hour, which is equivalent at maximum displacement and piston stroke, to approximately 6 drops-per-hour leakage.
4. Carefully relieve the pump pressure and remove the pressure gage.



1. Piston.
2. Gland nut.
3. Pump body.
4. Spring.
5. Piston ball check.
6. Fitting.
7. Lockring.
8. O-ring packing.
9. Piston ball check seat.
10. Suction ball check.

216.72

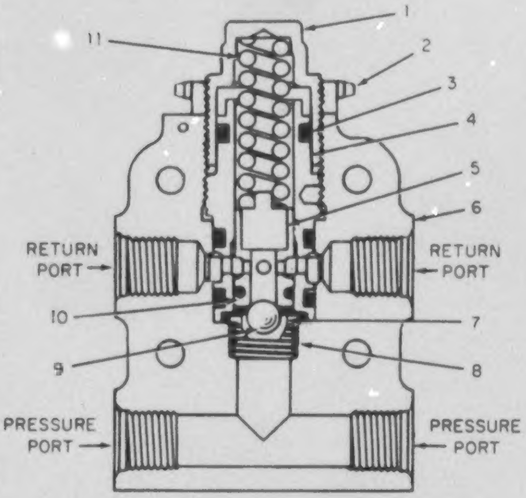
Figure 6-32.—Hydraulic hand pump.

5. Connect a 1,500-psi pressure relief valve to the pressure port.

6. Actuate the pump piston at a rate of 60 full cycles per minute. The maximum leakage past the pump gland should not exceed one drop per 50 cycles of pump actuation at 1,500-psi pressure output.

7. Connect the suction port to a vacuum gage. Operate the pump at a rate of 15 cycles per minute. The minimum vacuum should be 25 inches of mercury.

8. If the pump being tested is not to be installed on an aircraft immediately, flush it with preservative oil (MIL-H-6083) and plug its ports.



1. **Adjusting screw.**
2. **Checknut.**
3. **O-ring packing.**
4. **Main valve housing.**
5. **Spring guide.**
6. **Body.**
7. **Ball holder assembly.**
8. **Ball holder spring.**
9. **Ball.**
10. **Main valve.**
11. **Main valve spring.**

216.73

Figure 6-33.–Emergency system pressure relief valve.

Pressure Relief Valve

The pressure relief valve (fig. 6-33) in the hand pump emergency power system described here is located downstream of the emergency system filter. The relief valve relieves the hand pump pressure when: (1) none of the emergency selector valves have been actuated, or (2) the emergency landing gear hydraulic system pressure or the emergency torpedo bay door hydraulic system pressure has exceeded the relief valve cracking point. The emergency relief valve has a maximum full flow pressure of 1.2 gpm at 1,900-psi pressure, and a minimum reseat pressure of 1,517 psi. Excess fluid is returned to the main reservoir.

The emergency relief valve contains a main valve, main valve housing, main valve spring, ball, ball holder, and ball holder spring. If excessive emergency pressure is built up by the emergency hand pump, the main valve ((10) of fig. 6-33) overcomes main valve spring (11) pressure and the main valve is unseated from the ball (9). This allows the excess pressure to be relieved by passing fluid through the return port and to the main reservoir. When the hydraulic pressure decreases, the main valve is reseated on the ball and fluid flow out of the return port ceases.

MAINTENANCE.–An emergency system pressure relief valve which does not relieve at the specified pressure may be adjusted in the following manner:

1. Remove the valve from the aircraft and plug one pressure port and one return port.
2. Connect a pressure gage which is calibrated to indicate 2,000 psi and a suitable hand pump to the open pressure post on the valve.

NOTE: The hand pump should be connected to a supply of clean hydraulic fluid (MIL-H-5606).

3. Remove the adjusting screw lock wire and while holding the adjusting screw stationary, back off the checknut 1 or 2 turns.
4. Operate the hand pump to build up hydraulic pressure until fluid flows from the return port. Carefully observe gage and return port to determine the reseat point.
5. Turn the adjusting screw in the direction necessary to correct the reseat point.

NOTE: Turn the adjusting screw clockwise to raise the reseat point and counterclockwise to lower the reseat point.

6. Repeat steps 4 and 5 until the desired setting of 1,517 psi minimum reseat point is obtained.
7. Hold the adjusting screw stationary and tighten the checknut.
8. Cycle the relief valve through the reseating operation at least five times to ensure correct setting. Lock wire the adjusting screw.
9. Remove the hand pump and pressure gage, and reinstall the relief valve on the aircraft.

NOTE: If the valve is not to be installed on an aircraft when adjustment is completed, the valve should be flushed with hydraulic

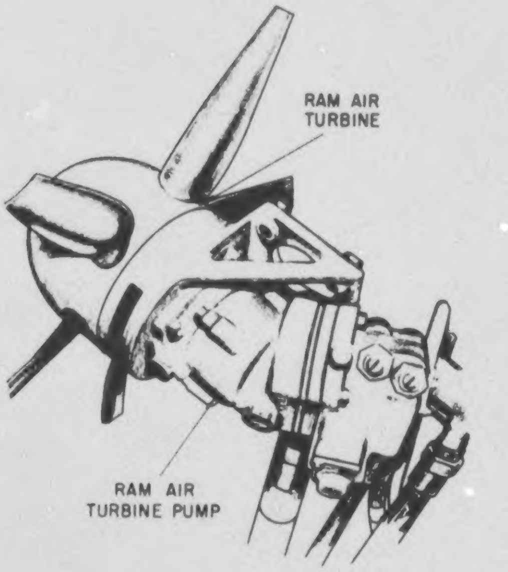


Figure 6-34.—Ram air turbine installation (hydraulic pump only).

preservative oil (MIL-H-6083) and all ports plugged.

Reservoir

The emergency reservoir used in this installation is a cylindrically shaped nonpressurized tank. Normally, the emergency reservoir is replenished by servicing the main reservoir, but it can be filled in flight through an emergency filler.

NOTE: The emergency reservoir filler should be used only after actuation of the emergency hand pump fails to complete the necessary emergency operations. Opening the emergency reservoir fillercap when the main reservoir contains fluid will cause fluid to be spilled into the fuselage.

RAM AIR TURBINE DRIVEN EMERGENCY SYSTEM

Emergency hydraulic power is supplied by a ram air turbine on most high performance aircraft. This ram air turbine may operate a hydraulic pump only (fig. 6-34), or may be a dual purpose unit which is used to power a hydraulic pump and an emergency electrical generator. See fig. 6-35. Aircraft which use a turbine to power a hydraulic pump only usually have a second ram air turbine or a hydraulic motor to drive the emergency electrical generator.

The ram air turbine is mounted in the aircraft in such a manner that it can be extended into the airstream by manually actuating the turbine release handle in the cockpit. The turbine release system is a manually controlled pneumatic or hydraulic system and does not require electrical power for its operation.

The ram air turbine driven emergency hydraulic pump is connected parallel to one of the aircraft power control systems and utilizes that system's components and plumbing to route operating pressure to the essential actuating systems. (Most ram air turbine hydraulic systems are used to power the primary flight controls in case of a normal power control system failure.)

Most ram air turbine emergency hydraulic systems consist of a ram air turbine, a hydraulic pump, and (in installations which use a constant displacement pump) a pressure regulator.

Ram Air Turbine

The ram air turbine is pneumatically or hydraulically extended into the airstream or stowed in the fuselage by the ram air turbine actuating system. In the extended position, the turbine provides the rotational power to drive the emergency hydraulic pump and in some installations it also drives the electrical generator. The ram air turbine unit described in this chapter is the dual-purpose unit used on the A7A/B aircraft. See fig. 6-35.

PRINCIPLES OF OPERATION

Emergency Power Package Operation. When the emergency power package (figs. 6-36 through 6-38) is extended during flight, torque developed by aerodynamic force of the airstream on the turbine fan blades causes the

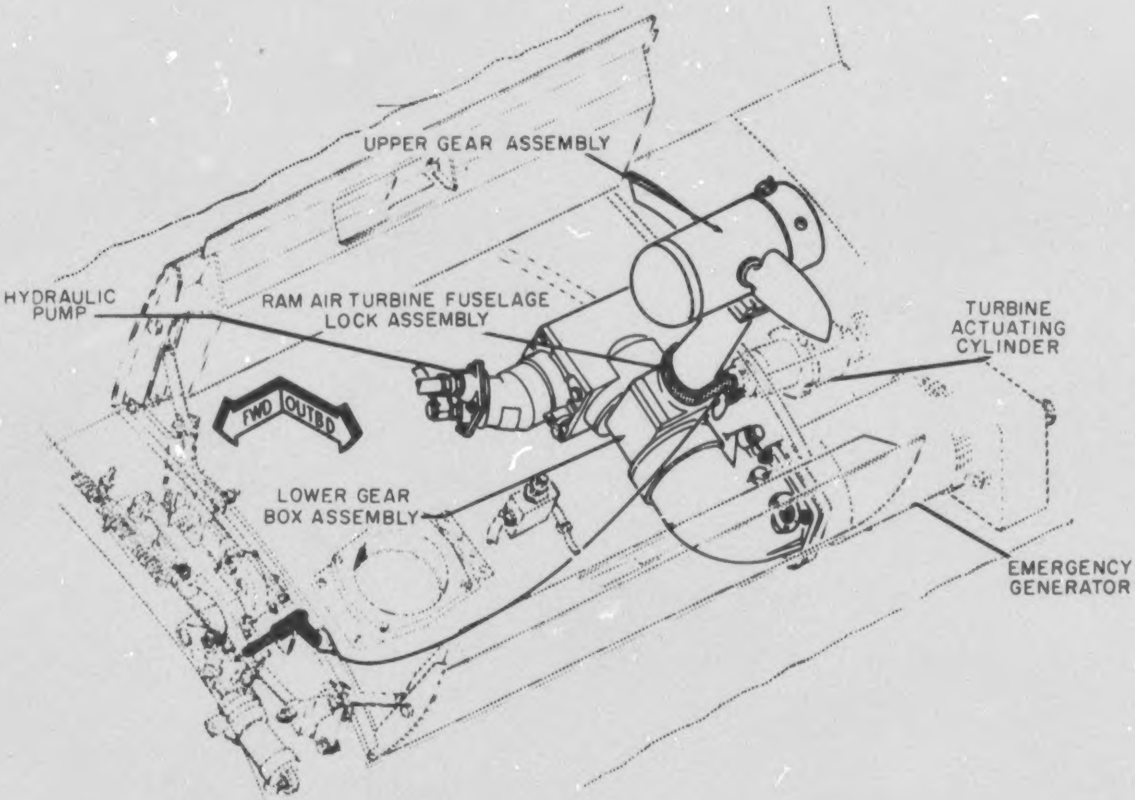


Figure 6-35.–Ram air turbine installation (dual-purpose unit).

fan and turbine shaft to rotate. To allow the turbine shaft speed to promptly come up to 11,400 rmp, the lower extreme of the governor speed control range, the fan blades are initially maintained at a relatively low pitch position by the turbine governor. When shaft speed exceeds 11,400 rpm, the governor rotates the fan blades in the direction of high pitch. When shaft speed is stabilized at approximately 12,000 rpm, the normal operating speed and upper limit of the governor speed control range, the blades are positioned in relatively high pitch.

The governor maintains constant shaft speed of the turbine. As airspeed is increased, or load demands on the turbine shaft are decreased, centrifugal and acceleration forces acting on the governor cause the fan blades to increase pitch and resist an increase in turbine shaft speed. If airspeed is decreased or load demands on the turbine shaft are increased, decreased centrifugal and acceleration forces on the governor cause the fan blades to reduce pitch, preventing a decrease in shaft speed.

Emergency Power Package Hydraulic System Operation

The emergency hydraulic pump is a piston type, fixed-displacement pump which supplies hydraulic fluid to the PC No. 1 hydraulic supply system when the emergency power package is in operation. The pump is basically a fixed cylinder barrel having seven pistons. The pistons are made to reciprocate by a rotating inclined cam plate. Complete stroking of the pistons is accomplished by holding the pistons against the rotating cam with a holddown plate.

Since the pump is a fixed-displacement type, the available flow to the airplane hydraulic system is a direct function of turbine shaft speed which is controlled by the turbine governor assembly. Therefore, the pump is sized to provide the minimum required flow of 6.75 gpm when shaft speed is 11,400 rpm, the lower limit of the governor speed control range.

Hydraulic pressure provided by the pump in the PC No. 1 hydraulic supply system is primarily a function of airspeed. At 128 to 132 knots equivalent airspeed (KEAS), approximately 710-psi hydraulic pressure is available. At 172 to 178 KEAS, the pressure increases to approximately 1,065 psi. At 197 to 203 KEAS, the pressure is approximately 2,020 psi.

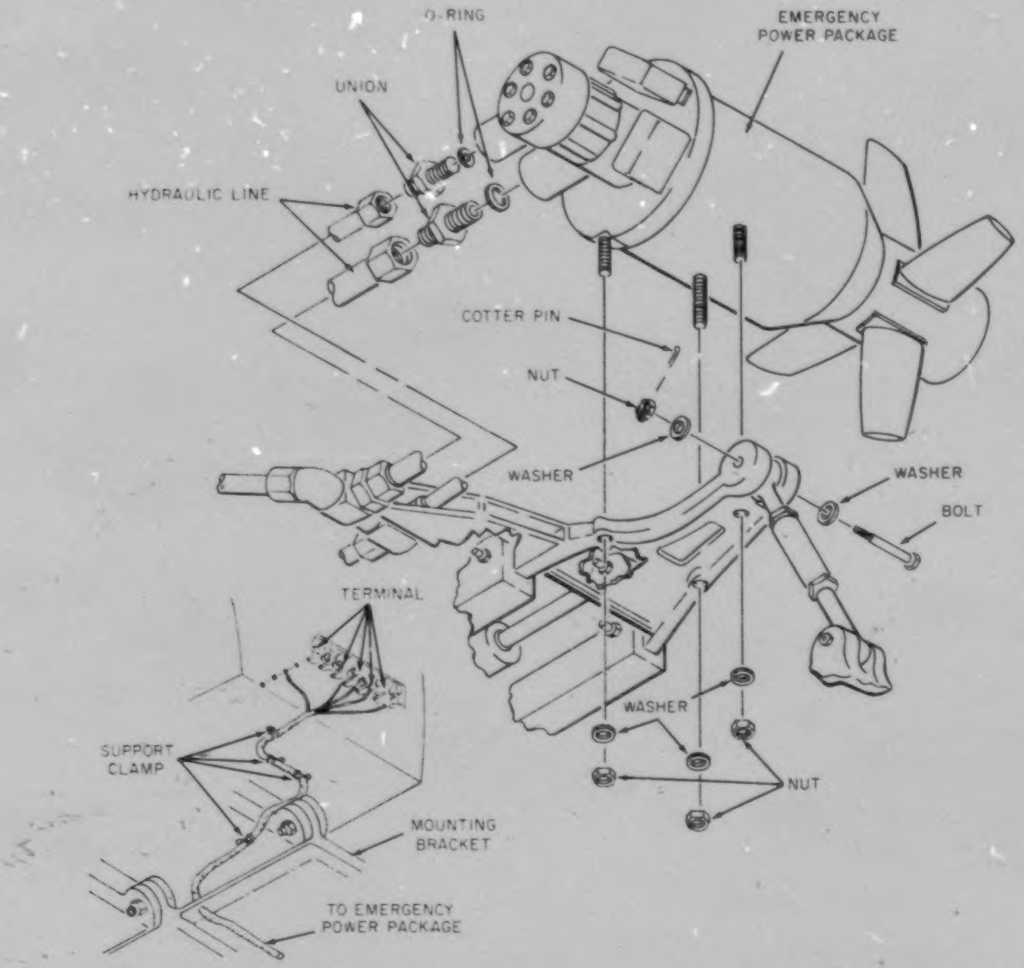
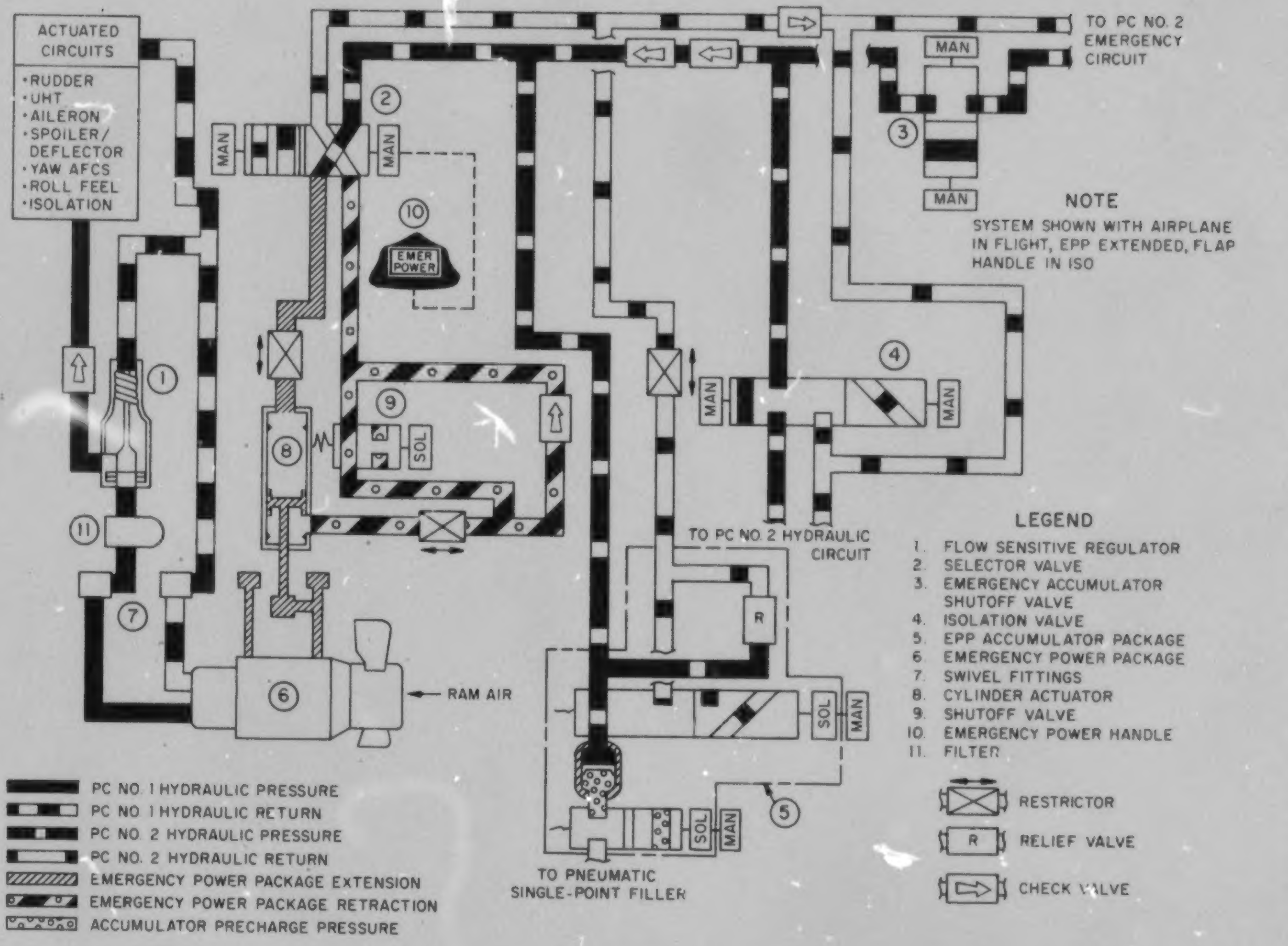
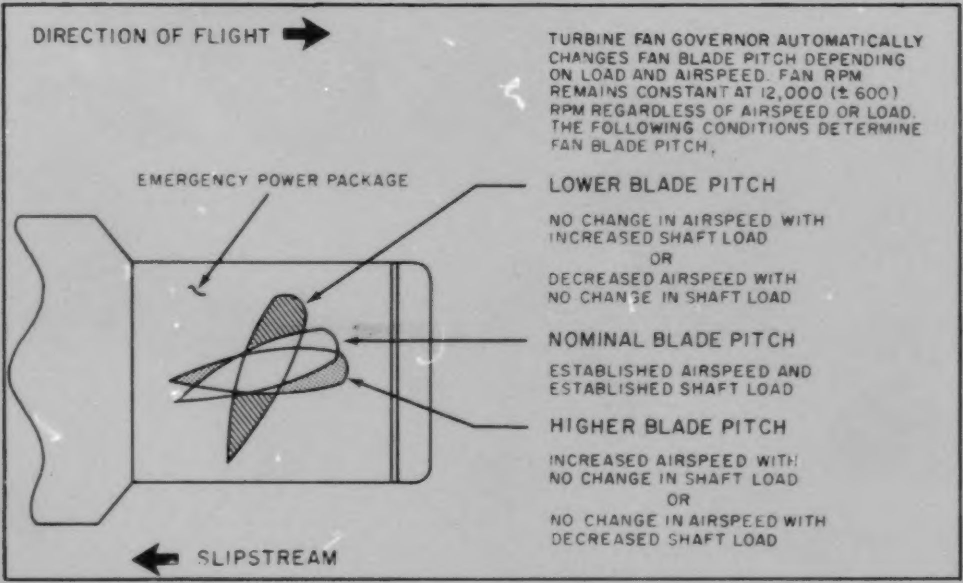

O-RING
EMERGENCY POWER PACKAGE
UNION
HYDRAULIC LINE
COTTER PIN
NUT
WASHER
WASHER
BOLT
TERMINAL
WASHER
SUPPORT CLAMP
NUT
MOUNTING BRACKET
TO EMERGENCY POWER PACKAGE

Figure 6-36.—Emergency power package removal and installation. 216.244


ACTUATED CIRCUITS
•RUDDER
•UHT
•AILERON
•SPOILER/ DEFLECTOR
•YAW AFCS
•ROLL FEEL
•ISOLATION
TO PC NO. 2 EMERGENCY CIRCUIT
MAN
MAN
MAN
MAN
MAN
MAN
MAN
MAN
SOL
SOL
SOL
EMER POWER
R
RAM AIR
TO PC NO. 2 HYDRAULIC CIRCUIT
TO PNEUMATIC SINGLE-POINT FILLER
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
NOTE
SYSTEM SHOWN WITH AIRPLANE IN FLIGHT, EPP EXTENDED, FLAP HANDLE IN ISO
LEGEND
1. FLOW SENSITIVE REGULATOR
2. SELECTOR VALVE
3. EMERGENCY ACCUMULATOR SHUTOFF VALVE
4. ISOLATION VALVE
5. EPP ACCUMULATOR PACKAGE
6. EMERGENCY POWER PACKAGE
7. SWIVEL FITTINGS
8. CYLINDER ACTUATOR
9. SHUTOFF VALVE
10. EMERGENCY POWER HANDLE
11. FILTER
RESTRICTOR
RELIEF VALVE
CHECK VALVE
PC NO. 1 HYDRAULIC PRESSURE
PC NO. 1 HYDRAULIC RETURN
PC NO. 2 HYDRAULIC PRESSURE
PC NO. 2 HYDRAULIC RETURN
EMERGENCY POWER PACKAGE EXTENSION
EMERGENCY POWER PACKAGE RETRACTION
ACCUMULATOR PRECHARGE PRESSURE

216.245

Figure 6-37.—Emergency power package schematic diagram.


DIRECTION OF FLIGHT
TURBINE FAN GOVERNOR AUTOMATICALLY CHANGES FAN BLADE PITCH DEPENDING ON LOAD AND AIRSPEED. FAN RPM REMAINS CONSTANT AT 12,000 (± 600) RPM REGARDLESS OF AIRSPEED OR LOAD. THE FOLLOWING CONDITIONS DETERMINE FAN BLADE PITCH,
EMERGENCY POWER PACKAGE
LOWER BLADE PITCH
NO CHANGE IN AIRSPEED WITH INCREASED SHAFT LOAD
OR
DECREASED AIRSPEED WITH NO CHANGE IN SHAFT LOAD
NOMINAL BLADE PITCH
ESTABLISHED AIRSPEED AND ESTABLISHED SHAFT LOAD
HIGHER BLADE PITCH
INCREASED AIRSPEED WITH NO CHANGE IN SHAFT LOAD
OR
NO CHANGE IN AIRSPEED WITH DECREASED SHAFT LOAD
SLIPSTREAM

216.246

Figure 6-38.—Emergency power package blade pitch control diagram.

Emergency hydraulic pressure and return line fluid are directed through swivel fittings, located at the emergency power package door hinge line. The fittings allow extension and retraction of the unit. One fitting is connected to the pressure line and one to the return line of the PC No. 1 hydraulic supply system, and to the emergency hydraulic pump pressure and return lines. Pressurized fluid flows from the pump through the pressure line swivel fitting and a filter to a flow-sensitive pressure regulator. The regulator determines the amount of fluid permitted to flow through a check valve to the PC No. 1 system pressure line.

The flow-sensitive regulator performs the following three functions in the system—it bypasses to the return line any excess fluid flow; it prevents the pump from stalling during overload conditions when no hydraulic flow is required; and it reduces the hydraulic load on the turbine to a minimum during acceleration.

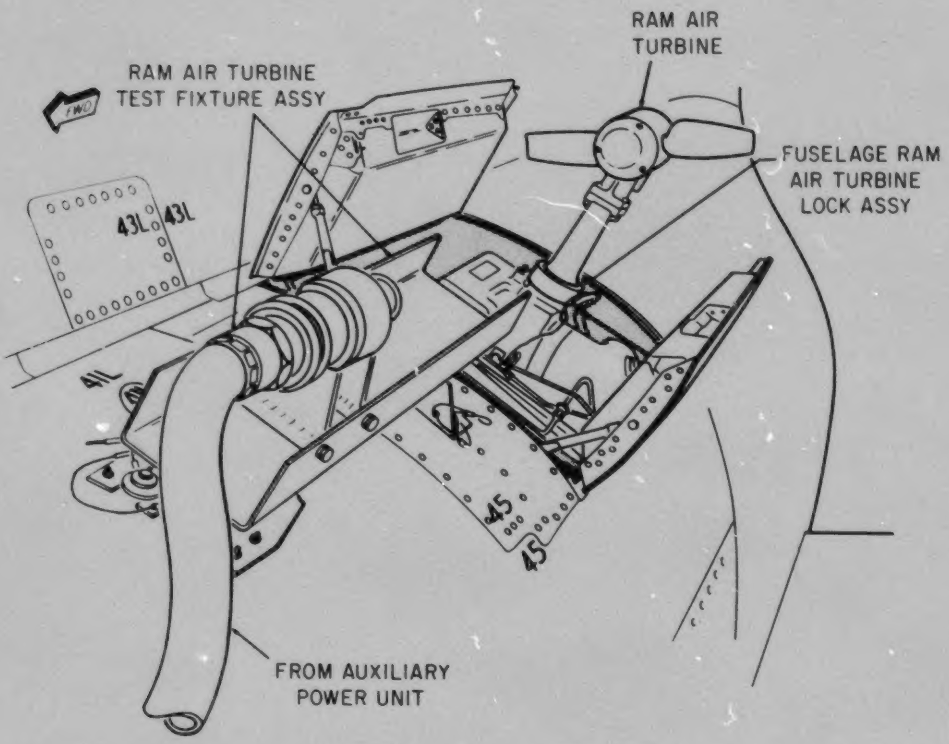
Hydraulic system pressure, with the emergency power package extended, is transmitted to the hydraulic pressure indicator by a pressure switch and transmitter unit. For additional information on hydraulic indicating system operation, refer to NAVAIR 01-45AAA-2-14, *Hydraulic and Pneumatic Systems.*

MAINTENANCE.—Maintenance of the ram air turbine is limited to testing, and removal and installation. The turbine is not repairable at the fleet level of maintenance and should be returned to supply for disposition.

Operational testing of the ram air turbine is accomplished by attaching a fixture (fig. 6-39) to the aircraft to direct a flow of air pressure on the turbine blades. (NOTE: The design of this fixture varies with the type of aircraft.) Air pressure is supplied by using a gas turbine compressor as specified in the applicable Maintenance Instructions Manual.

CAUTION: The ram air turbine should be locked in the extended position with the necessary ground safety locks to prevent injury to personnel.

The ram air turbine driven emergency hydraulic system should be checked for leakage and specified pressure output while performing the test. One aircraft manufacturer requires the


RAM AIR TURBINE
RAM AIR TURBINE TEST FIXTURE ASSY
FWD
FUSELAGE RAM AIR TURBINE LOCK ASSY
43L
43L
41L
45
45
FROM AUXILIARY POWER UNIT

216.77

Figure 6-39.—Ram air turbine functional test.

comparison of the hydraulic pressure indication with the emergency generator frequency output to determine if the turbine and hydraulic pump is functioning properly.

BACKUP FLIGHT CONTROL MOTOR/PUMP SYSTEM

As an additional power source to supply hydraulic pressure to the rudder and stabilizer of the later models of the A-6 aircraft, a backup flight control system has been installed. This system is only intended to get the aircraft stabilized in the event the primary hydraulic systems fail. It can be used for limited maneuvers, and under optimum conditions can be utilized to land the aircraft. The system is powered by an electric motor driven constant displacement hydraulic pump capable of putting out 3 gallons per minute at 1,000 psi output pressure to 0 gpm at cutoff pressure. If either or both of the primary hydraulic systems are lost, the backup system will provide power to the rudder and stabilizer actuators. If both systems fail, the backup system is automatically actuated without disrupting operation of the flight controls. When operated on the backup system pressure, the available rate of operation for the stabilizer is 10 percent of its normal rate and for the rudder, 33 percent of normal system operation. This is due to the low displacement output of the pump, which cannot keep up with rapid inputs. The backup flight control system is described and illustrated in chapter 9 of this manual.

PNEUMATIC POWER SYSTEMS

The pneumatic power system supplies compressed air for various normal and emergency pneumatic actuating systems. The compressed air is stowed in storage cylinders in the actuating systems until required by actuation of the system. These cylinders and the power system manifold are initially charged with compressed air or nitrogen from an external source via a single air charge valve. In flight, the air compressor replaces the air pressure and volume lost through leakage, thermal contraction, and actuating system operation.

The air compressor is supplied with supercharged air from the engine bleed air system. This ensures an adequate supply of air to the compressor at all altitudes.

The air compressur may be driven by an electric motor or a hydraulic motor. The system descirbed in the following paragraphs is hydraulically driven. See fig. 6-40.

System Operation

The compressor inlet air is filtered through a high temperature 10-micron filter and pressure regulated by an absolute pressure regulator to provide a stabilized source of air for the compressor.

The aircraft utility hydraulic system provides power to operate the hydraulic motor driven air compressor. The air compressor hydraulic actuating system consists of a solenoid-operated selector valve, flow regulator, hydraulic motor, and motor bypass (case drain) line check valve. When energized, the selector valve allows the system to be pressurized and run the hydraulic motor; when deenergized the valve blocks off utility system pressure, stopping the motor. The flow regulator, compensating for the varying hydraulic system flow and pressures, meters the flow of fluid to the hydraulic motor to prevent excessive speed variation and/or overspeeding of the compressor. A check valve in the motor bypass line prevents system return line pressures from entering the motor and stalling it.

The air compressor is the pneumatic system's pressurizing air source. The compressor is activated or deactivated by the manifold pressure sensing switch which is an integral part of the moisture separator assembly.

The moisture separator assembly is the pneumatic system's pressure sensor-regulator and relief valve. The manifold (system) pressure switch governs the operation of the air compressor. When the manifold pressure drops below 2,750 psi, the pressure sensing switch closes, energizing the separator's moisture dump valve and the hydraulic selector valve which activates the air compressor.

When the manifold pressure builds up to 3,150 psi, the pressure sensing switch opens, deenergizing the hydraulic selector valve to deactivate the air compressor and dump valve, thus venting overboard any moisture accumulated in the separator.

The safety fitting, installed at the inlet port of the moisture separator, protects the separator from internal explosions due to hot carbon particles or flames that may be emitted from the air compressor.

A chemical drier further reduces the moisture content of the air emerging from the moisture separator.

A pressure transmitter senses and electrically transmits a signal to the pilot's cockpit pneumatic pressure indicator. The indicating system is an autosyn type that functions exactly like the hydraulic indicating systems.

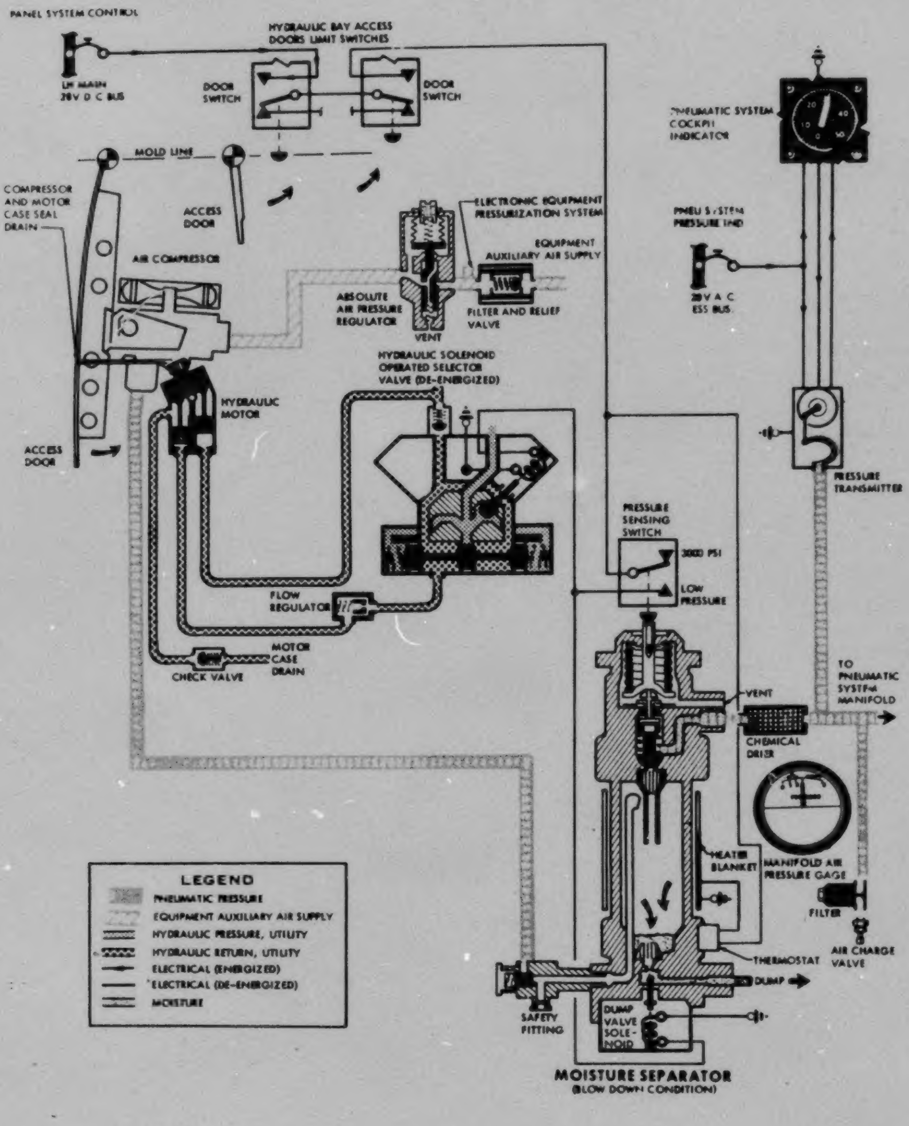
An air charge valve provides the entire pneumatic system with a single external ground servicing point. An air pressure gage, located near the aircharge valve, is used in servicing the pneumatic system. This gage indicates the manifold pressure.

An air filter (10-micron element) in the ground air charge line prevents the entry of particle impurities into the system from the ground servicing power source.

COMPONENTS

Air Compressor

The air compressor maintains the aircraft pneumatic system pressurization during flight. The air compressor is a four-stage radial compressor which is hydraulic motor driven.


PANEL SYSTEM CONTROL
LH MAIN 28V D C BUS
HYDRAULIC BAY ACCESS DOORS LIMIT SWITCHES
DOOR SWITCH
DOOR SWITCH
MOLD LINE
COMPRESSOR AND MOTOR CASE SEAL DRAIN
ACCESS DOOR
AIR COMPRESSOR
ELECTRONIC EQUIPMENT PRESSURIZATION SYSTEM
EQUIPMENT AUXILIARY AIR SUPPLY
ABSOLUTE AIR PRESSURE REGULATOR
FILTER AND RELIEF VALVE
VENT
HYDRAULIC SOLENOID OPERATED SELECTOR VALVE (DE-ENERGIZED)
HYDRAULIC MOTOR
ACCESS DOOR
PNEUMATIC SYSTEM COCKPIT INDICATOR
PNEU SYSTEM PRESSURE IND
28V A C ESS BUS
PRESSURE TRANSMITTER
PRESSURE SENSING SWITCH
3000 PSI
LOW PRESSURE
FLOW REGULATOR
MOTOR CASE DRAIN
CHECK VALVE
TO PNEUMATIC SYSTEM MANIFOLD
VENT
CHEMICAL DRIER
HEATER BLANKET
MANIFOLD AIR PRESSURE GAGE
FILTER
AIR CHARGE VALVE
THERMOSTAT
DUMP
SAFETY FITTING
DUMP VALVE SOLENOID
MOISTURE SEPARATOR (BLOW DOWN CONDITION)
LEGEND
PNEUMATIC PRESSURE
EQUIPMENT AUXILIARY AIR SUPPLY
HYDRAULIC PRESSURE, UTILITY
HYDRAULIC RETURN, UTILITY
ELECTRICAL (ENERGIZED)
ELECTRICAL (DE-ENERGIZED)
MOISTURE

216.78

Figure 6-40.–Pneumatic power system.

The operation of the air compressor is as follows:

Air entering the compressor through the air inlet cap on the first stage cylinder head passes through a filter to remove any particles which might damage the internal components of the assembly. The filtered air is drawn through the intake valve into the first stage cylinder by means of the suction created on the downward (intake) stroke of the first stage piston.

On the upward or compression stroke, the intake valve is forced shut by the increasing pressure, and the spring-loaded discharge valve is forced open when the pressure reaches a predetermined value. The compressed air is directed through the discharge valve and into the first intercooler connected to the first stage head. As the compressed air passes through the intercooler, the heat created during compression is dissipated through forced convection by the airflow from the fan directed over the intercoolers. The flow of cooled compressed air next passes through the first stage relief valve (connected between the first intercooler and the inlet port in the second stage cylinder head) and then into the second stage cylinder during the downward (intake) stroke of the second stage piston.

The operation inside the three subsequent stages is identical to that of the first stage, with the exception that a pressure relief valve is not provided between the outlet of the third stage and the inlet of the fourth stage. The airflow in these subsequent stages is as follows—from the outlet in the second stage cylinder head through the second intercooler and past the second stage relief valve, and into the inlet in the third stage cylinder head; from the outlet in the third stage cylinder, through the third intercooler and the air filter, and into the inlet in the fourth stage cylinder head, through the bleed valve, and finally to the high-pressure air outlet.

This compressor is lubricated with oil which is drawn from an externally mounted oil sump. This oil is withdrawn from the sump through a filter by means of a positive displacement pump. The pump is driven through a direct connection to the compressor crankshaft. A passage in the crankshaft directs the oil to the cam journal, and drilled holes in the cam direct the oil to the first stage piston pin and to the cam plunger bearing surfaces of the other three stages. The oil which collects in the compressor crankcase splash-lubricates the cylinder walls. An equalizer tube, connected between the crankcase and the oil sump, maintains the pressure within each of these components at approximately equal value, thereby allowing a gravity operated oil return from the crankcase to the oil sump.

The high-pressure air exiting from the fourth stage of the air compressor is directed through a bleed valve (controlled by an oil pressure tap taken on the pressure side of the oil pump) to the high-pressure air outlet. The oil pressure applied to the piston of the bleed valve maintains the valve piston in the closed position. When the oil pressure drops (due either to restriction of oil flow or to stopping of the compressor), the spring within the bleed valve repositions the bleed valve piston, thereby connecting the in port and the drain port of the valve. This action unloads the pressure from the compressor and purges the line of moisture.

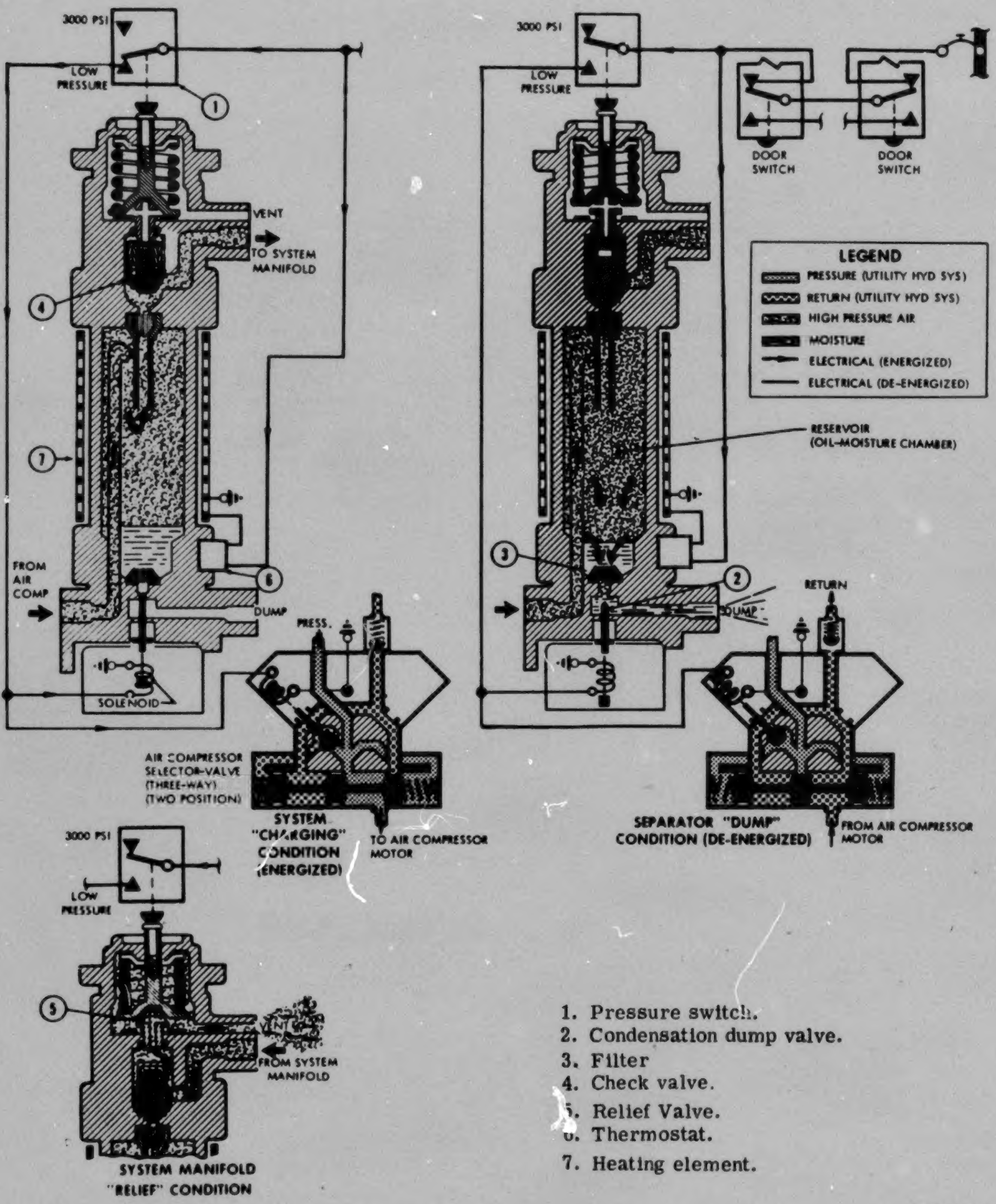
Air Filters

GROUND CHARGING INLET FILTER.—The air filter through which the ground charging air passes is located immediately upstream of the air charge valve. Its purpose is to prevent the entry of particle impurities into the system from the ground servicing source. The filter assembly is made up of three basic components—body, element, and bowl. The filter element is a 10-micron rated filtering capacity, stainless steel, wire mesh, cylindrically shaped, reusable unit. The bowl, which is the supporting chamber for the filter element, is attached to the filter body with an applied torque of 150 inch-pounds.

COMPRESSOR INLET FILTER.—The pneumatic system air compressor inlet air is filtered through a high temperature filter. Its purpose is to prevent particles of foreign matter from entering the compressor's absolute pressure regulator, thereby causing it to malfunction. The filter is an inline full flow type filter (with integral relief valve) housed in a cylindrical body. The filter element (rated at 10 microns) is of woven monel wire construction. The integral relief valve will allow air to flow through the center of the element at a pressure differential of 50 psi and reseats at 32-psi minimum.

Moisture Separator

The moisture separator is the pneumatic power system's pressure-sensor-regulator and relief valve. The moisture separator is capable of removing up to 95 percent of the moisture from the air compressor discharge line. The automatically operated condensation dump valve purges the separator oil-moisture chamber by means of a blast of air (3,000 psi) each time the compressor shuts down. The separator assembly is made up of seven basic components (fig. 6-41), each of which performs a specific


3000 PSI
LOW PRESSURE
①
VENT
TO SYSTEM MANIFOLD
④
⑦
⑥
FROM AIR COMP
DUMP
SOLENOID
PRESS.
AIR COMPRESSOR SELECTOR-VALVE (THREE-WAY) (TWO POSITION)
SYSTEM "CHARGING" CONDITION (ENERGIZED)
TO AIR COMPRESSOR MOTOR
3000 PSI
LOW PRESSURE
DOOR SWITCH
DOOR SWITCH
LEGEND
PRESSURE (UTILITY HYD SYS)
RETURN (UTILITY HYD SYS)
HIGH PRESSURE AIR
MOISTURE
ELECTRICAL (ENERGIZED)
ELECTRICAL (DE-ENERGIZED)
RESERVOIR (OIL-MOISTURE CHAMBER)
③
②
RETURN
DUMP
SEPARATOR "DUMP" CONDITION (DE-ENERGIZED)
FROM AIR COMPRESSOR MOTOR
3000 PSI
LOW PRESSURE
⑤
VENT
FROM SYSTEM MANIFOLD
SYSTEM MANIFOLD "RELIEF" CONDITION

1. Pressure switch.
2. Condensation dump valve.
3. Filter
4. Check valve.
5. Relief Valve.
6. Thermostat.
7. Heating element.

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Figure 6-41.–Moisture separator (operation).

function. The components are described in the following paragraphs.

PRESSURE SWITCH.–The pressure switch controls system pressurization by sensing the system pressure between the check valve and the relief valve. It electrically energizes the air compressor solenoid-operated selector valve when the system pressure drops below 2,750 psi, and deenergizes the selector valve when the system pressure reaches 3,100 psi.

CONDENSATION DUMP VALVE.–The condensation dump valve solenoid is energized and deenergized by the pressure switch. When energized it prevents the air compressor from dumping air overboard, and when deenergized it completely purges the separator reservoir and lines up to the air compressor.

FILTER.–The filter protects the dump valve port from becoming clogged and thus ensures proper sealing of the passage between the reservoir and the dump port.

CHECK VALVE.–The check valve protects the system against pressure loss during the dumping cycle and prevents backflow through the separator to the air compressor during the relief condition.

RELIEF VALVE.–The relief valve protects the system against overpressurization (thermal expansion). The relief valve opens when the system pressure reaches 3,750 psi and reseats at 3,250 psi.

THERMOSTAT AND HEATING ELEMENT.–The thermostatically controlled wrap-around blanket type heating element prevents freezing of the moisture within the reservoir, due to low temperature atmospheric conditions. The thermostat closes at 40°F and opens at 60°F.

MAINTENANCE

Maintenance of the pneumatic power system consists of servicing, troubleshooting, removal and installation of components, and operational testing.

Servicing

The air compressor lubricating oil level should be checked on the daily inspection in accordance with the applicable Maintenance Requirements Cards. The oil level is indicated by means of a sight gage. When refilling the compressor oil tank, the oil (type specified in the applicable Maintenance Instructions Manual) is added until the tank overflows. After the oil is added, ensure that the filler plug is torqued and safety wire is properly installed.

The pneumatic system should be purged periodically to remove the contamination, moisture, and oil from the components and lines. Purging of the pneumatic system is accomplished by pressurizing the system and removing the plumbing from various components throughout the system. Removal of the pressurized lines will cause a high rate of airflow through the system. This airflow will cause the foreign matter to be exhausted from the system.

NOTE: If an excessive amount of foreign matter, particularly oil, is exhausted from any one system, the lines and components should be removed and cleaned or replaced.

Upon the completion of pneumatic system purging and later reconnecting all the system components, the system air bottles should be drained to exhaust any moisture or impurities which may have accumulated there.

After draining the air bottles, the system should be serviced with nitrogen or clean dry compressed air. The system should then be given a thorough operational check and an inspection for leaks and security.

Troubleshooting

Troubleshooting, or fault isolation, is a systematic method of determining the cause of a system malfunction. This is normally accomplished by studying the system diagrams (system flow schematics and electrical diagrams) and the troubleshooting charts furnished by the aircraft manufacturer in the applicable Maintenance Instructions Manual.

The troubleshooting charts supply the cause, isolation procedure, and the remedy for some of the more common malfunctions with will cause

Table 6-3.–Pneumatic system troubleshooting chart

Probable cause	Isolation procedure	Remedy
TROUBLE: AIR COMPRESSOR RUNS CONTINUOUSLY OR OPERATES AT FREQUENT INTERVALS (SYSTEM LOSING AIR PRESSURE)		
Line or component failure.	Perform system pressure leakage test. Check each of the system's air gages for below normal pressure indication. Air charge the system and listen for sounds of escaping air at the component of the leaking system. If leaking air cannot be located by sound or feel, apply a mild soap solution to the suspected system lines and components.	Repair or replace the faulty unit. Air charge the system. Perform system pressure leakage and operational check.
TROUBLE: AIR COMPRESSOR RUNS CONTINUOUSLY (SYSTEM NOT LEAKING AIR)		
Air compressor solenoid operated selector valve.	Relieve system (nanifold) pressure to zero psi; apply external hydraulic power to the utility system. If the air compressor runs without applied electrical power, the hydraulic selector solenoid is stuck in the energized position.	Replace the air compressor hydraulic selector valve. Perform operational checks in accordance with the Maintenance Instructions Manual.
Safety fitting rupture disc blown.	Visually examine the safety fitting rupture disc.	Replace the safety fitting and inspect the moisture separator for signs of damage.
Moisture separator assembly.	Activate the air compressor and perform the following steps: 1. Feel for exhausting air at the overboard dump line. If the air is dumping below 3,100 psi, the dump valve is either being held open by foreign matter or held in the deenergized position by the pressure switch. 2. Feel for exhausting air at the moisture separator relief valve vent. If air is exhausting from the vent port, the relief valve is cracking at too low a pressure, or has failed in the relief (open) position.	Replace the moisture separator.

the pneumatic system to become inoperative or uncontrollable. These charts are organized in a definite sequence under each possible trouble, according to the probability of failure and ease of investigation. In order to obtain maximum value from these charts, they should be used systematically in accordance with the aircraft manufacturers' recommendations. A portion of the troubleshooting chart for the F-4 aircraft pneumatic system is shown in table 6-3.

Removal and Installation

When a component of an aircraft pneumatic system has been installed, replaced, disconnected, lines removed, or partially disassembled, the particular pneumatic system and all equipment affected thereby should be given a complete and thorough operational test. This test shold require complete system cycling until a sufficient check has been made to determine that its operation and adjustment are satisfactory.

When any work is performed on a pneumatic system component, the following procedure should be observed:

1. Prior to the removal of a component of a pneumatic system, relieve the system pressure.

2. Cap or plug disconnected lines and component ports immediately upon their being depressurized.

3. Prior to the installation of a system component (including line assemblies), refer to the applicable IPB to ensure that the latest configuration or material is being used.

4. Torque all lines and fittings to the values specified in the applicable Maintenance Instructions Manual.

NOTE: On one of the new naval aircraft, torque values are being placed on a tape adjacent to the line identification tape.

CHAPTER 7

BRAKE SYSTEM MAINTENANCE

Brake systems are designed to retard or stop aircraft motion on the ground and to aid in controlling the direction of the aircraft while taxiing. Provisions exist for applying either one or both brakes and for varying the braking action by the amount of movement or force exerted on the brake pedal.

Several naval aircraft have an antiskid system integrated with the wheel brake system to allow maximum braking, resulting in a short landing roll and skid free control until the aircraft comes to a stop.

Some aircraft brake systems also incorporate an antispin feature which is designed to provide antispin pressure to the brake assemblies during the landing gear retraction cycle.

TYPES OF BRAKE SYSTEMS

A large portion of maintenance effort expended by an AMH in an operating activity is directed toward troubleshooting and repairing of brakes and brake systems. A brake system is generally one of two major types—independent or power. Independent systems are so called because they operate independently of a pressure source other than the master cylinder. Power brake systems utilize utility or main hydraulic system pressure from the aircraft. The latter systems allow for higher brake line pressures than can be obtained with the former.

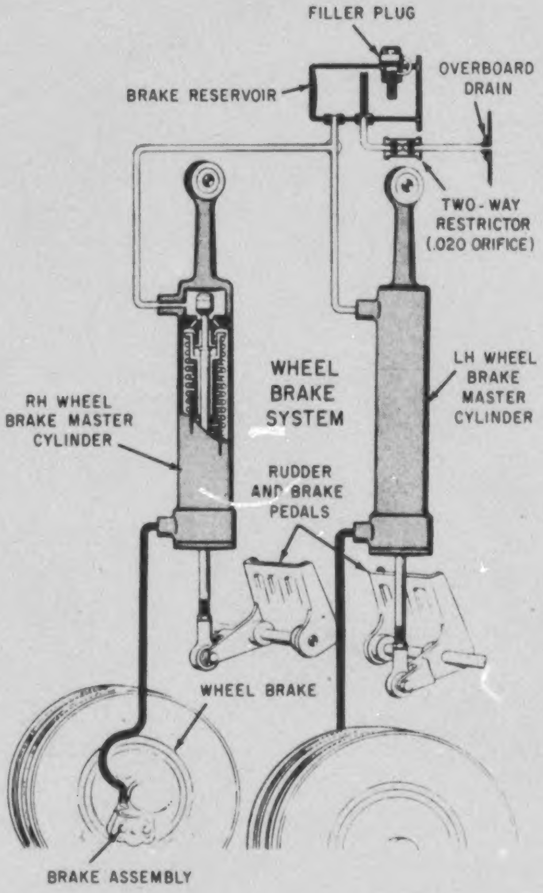
FILLER PLUG
BRAKE RESERVOIR
OVERBOARD DRAIN
TWO-WAY RESTRICTOR (.020 ORIFICE)
WHEEL BRAKE SYSTEM
LH WHEEL BRAKE MASTER CYLINDER
RH WHEEL BRAKE MASTER CYLINDER
RUDDER AND BRAKE PEDALS
WHEEL BRAKE
BRAKE ASSEMBLY

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Figure 7-1.—Independent brake system—hydraulic schematic.

INDEPENDENT SYSTEM

The main gear wheel brake control system in the A-4 aircraft is an example of an independent hydraulic system. Figure 7-1 is a schematic drawing of this system. In this system the main components are the master brake cylinders, the brake reservoir, and the brake assemblies. The master brake cylinders are attached to the rudder pedals. The brake assemblies are installed on the inboard sides of the main gear wheels. The left- and right-hand rudder pedals control the brakes on their respective sides.

Hydraulic pressure to the brakes is created by the master cylinder when the master cylinder piston is lowered. Lowering of the master cylinder piston is accomplished through mechanical linkage from the rudder pedal as that unit is tilted by pilot foot pressure.

The hydraulic pressure is directed from the lower port of the master brake cylinders to the brake cylinder pistons within the brake housing. The pressure in the brake system is dissipated when the spring action within the master cylinder returns the master cylinder piston to a neutral position. Once the system pressure is dissipated, the spring action of the return springs in the release units of the brake assemblies returns the brake cylinder pistons to a neutral or retracted position.

The upper port of the master cylinder is connected to the brake reservoir by the hydraulic fluid supply line. If heat from the brake assemblies causes expansion of the hydraulic fluid within the brake system, the fluid can pass through an orifice in the master cylinder piston head when the piston is in a neutral position.

Maintenance

The depth of maintenance allowable at the Intermediate and Organizational levels of maintenance varies with the components. System maintenance at the Organizational level generally consists of servicing, (bleeding, filling reservoir, brake assembly adjustment, etc.), troubleshooting, and miscellaneous parts replacement and "on aircraft" type repairs.

Bleeding may be accomplished with or without the use of a separate hydraulic power supply.

Reservoir maintenance is limited to servicing, removal, repair and parts replacement, testing and installation. The reservoir is mounted to the forward face of the rear bulkhead in the nose section. To avoid overfilling the reservoir, the aircraft should be at a 6-degree nose-up attitude during servicing. Filtered hydraulic fluid is gravity fed into the reservoir through the filler opening until the sight gage indicates it is full. The reservoir should not be overfilled. The area around the filler neck should be clean prior to removing the filler plug to prevent any form of contamination from being introduced into the reservoir and the brake system.

Maintenance of the reservoir, brake master cylinder, and the brake assembly is discussed later in this chapter.

Trouble Analysis

As with other systems, a troubleshooting chart is furnished in the Maintenance Instructions Manual for use in troubleshooting/analyzing main landing gear wheel and independent brake system malfunctions. Table 7-1 is an example of this type chart.

POWER BRAKE SYSTEMS

Power brake systems, in the broad sense of the term, may be further classified by the manner in which they utilize hydraulic power to provide braking action.

Power Brake Type

A true power brake system utilizes main system pressure to regulate and release the brakes. This system allows for braking action with much less pilot effort than with the independent system. With this type brake system a separate emergency brake system must be incorporated because the power brake valve cannot work without pressure supplied from the main hydraulic power system.

The brake system of the A-6 aircraft, illustrated in figure 7-2, provides an example of this type system. The brake system consists of brake pedals, power brake valves, brake assemblies, brake selector valve, accumulator, and brake cycles gage. An antiskid system is integrated with the brake system to prevent the main wheels from skidding and keeps braking action equalized during braking operations. The antiskid system is utilized only during landbased

Table 7-1.—Main landing gear wheels and brakes—troubleshooting

Trouble	Probable cause	Remedy
1. Wheel binds	a. Axle nut too tight.	Refer to paragraph 3-43.
	b. Damaged bearings.	Replace bearings.
	c. Damaged brake disc retaining keys.	Replace wheel.
2. Insufficient braking action	a. Air in lines.	Bleed brakes. (Refer to paragraph 3-144 or 3-145.)
	b. Brake reservoir vent clogged, creating vacuum which prevents fluid from flowing into system.	Clean vent.
	c. Leakage at piston or release body seals.	Replace seals.
3. Brakes drag	a. Worn lining.	Replace brake lining. (Refer to paragraph 3-134 or 3-165.)
	b. Dirt in piston.	Remove and clean piston.
	c. Master cylinder not returning to fully compressed position when brake released.	Adjust rudder pedal(s) to obtain full travel of master cylinder(s). (Refer to NavAir 01-40AVC-2-2.1.)
	d. Brake reservoir vent clogged.	Clean vent.
	e. Brake pistons improperly adjusted.	Replace pistons or release bodies in brake.
4. Brake failure	a. Overheating and improper cooling after maximum pressure application.	Allow minimum cooling period of 1 hour between maximum braking pressure stops; then test brakes. If no pressure, remove and repair brakes.
	b. Master cylinder leaking internally.	Replace cylinder.

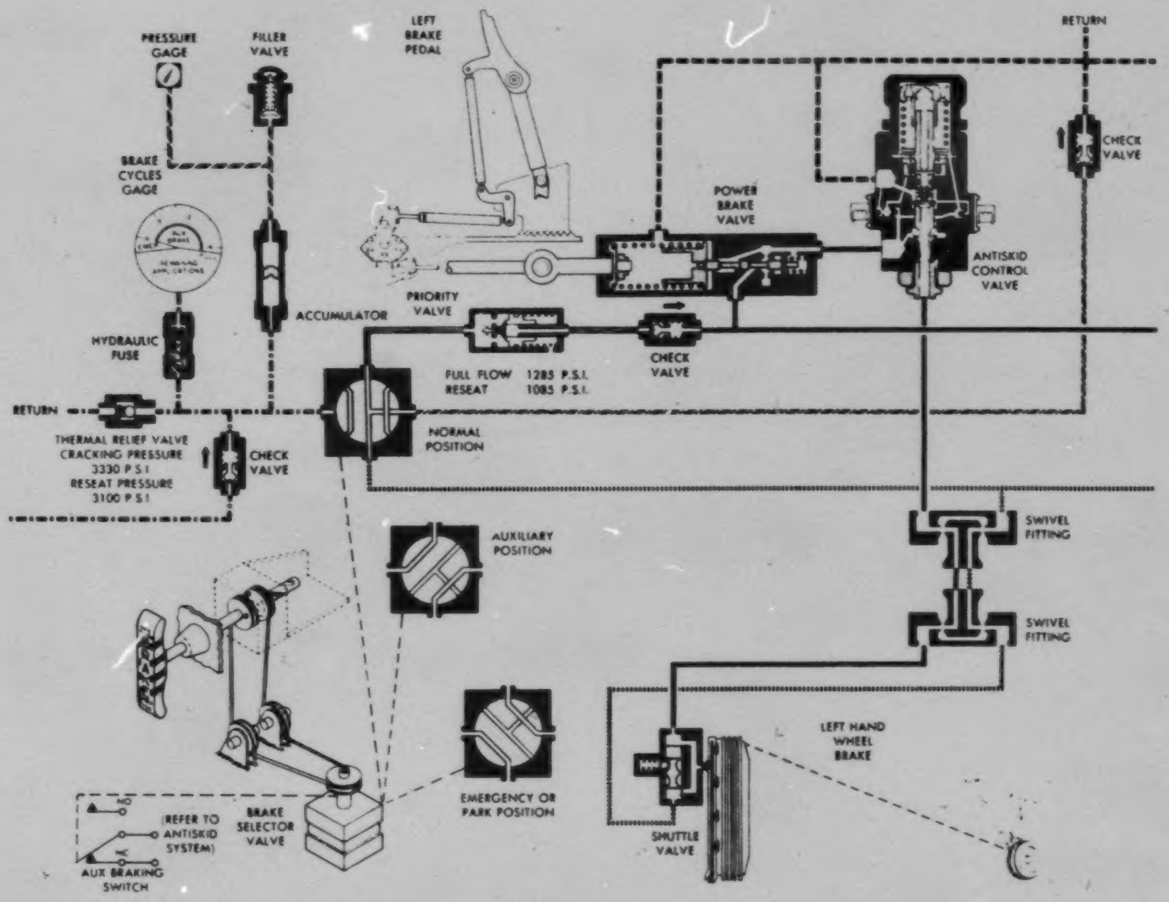
PRESSURE GAGE
FILLER VALVE
LEFT BRAKE PEDAL
RETURN
CHECK VALVE
BRAKE CYCLES GAGE
POWER BRAKE VALVE
ANTISKID CONTROL VALVE
PRIORITY VALVE
ACCUMULATOR
HYDRAULIC FUSE
FULL FLOW 1285 P.S.I.
RESEAT 1085 P.S.I.
CHECK VALVE
RETURN
THERMAL RELIEF VALVE
CRACKING PRESSURE
3330 P.S.I
RESEAT PRESSURE
3100 P.S.I
CHECK VALVE
NORMAL POSITION
SWIVEL FITTING
AUXILIARY POSITION
SWIVEL FITTING
LEFT HAND WHEEL BRAKE
EMERGENCY OR PARK POSITION
NO
(REFER TO ANTISKID SYSTEM)
NC
AUX BRAKING SWITCH
BRAKE SELECTOR VALVE
SHUTTLE VALVE

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Figure 7-2.—Wheel brake system (A-6A) (left side only).

operation. Antiskid systems are discussed in detail later in this chapter.

OPERATION.—Braking is accomplished by one of three methods: normal, auxiliary, or emergency. The method of operation is controlled by the brake handle, which controls the operation of the brake selector valve. When the brake handle is in the normal position, normal brake operation is controlled by foot pedal pressure to the power brake valve. If the combined hydraulic system fails, the brake handle can be turned clockwise to the auxiliary position. The auxiliary operation is the same as normal operation except that the supply of pressure is from the brake accumulator, and the antiskid system is rendered inoperative. Hydraulic fluid in the brake accumulator can be replenished and pressurized by use of the hydraulic handpump. The handpump can be operated from the nose-wheel well or the cockpit. On later version A-6s the brake accumulator may also be replenished by the electrically driven auxiliary hydraulic pump.

When pressure on the brake pedals fails to brake the aircraft, the emergency method of braking can be engaged by pulling the brake selector handle straight out from either the auxiliary or normal position. The emergency system operates directly from the brake accumulator to the wheel brakes, and the amount of braking pressure is not controlled by the brake pedals. The power brake valve is bypassed, and antiskid is electrically inoperative.

The emergency position is utilized for locking the brakes when parking the aircraft as well as for emergency stopping. Each application of the emergency or auxiliary system is registered in the brake cycles gage, which indicates the number of remaining applications based on the remaining accumulator pressure.

Power Boost Type

In a power boost type brake system, the pilot's foot pedal pressure is exerted hydraulically through a power boost brake cylinder to the brake assembly. Metered amounts of main system hydraulic pressure are used to multiply the mechanical force exerted on the brake pedals. The brake line pressure is therefore higher with less pedal force than would be required with an independent type master cylinder. When main system hydraulic pressure is not available, the power boost master cylinder acts as an independent master cylinder.

During actual braking, main system pressure does not enter the brake assembly line. The force exerted on the brake pedal by the pilot is transmitted to the piston shaft of the master cylinder. This mechanical action closes the passage between the brake and return chambers. Further travel of the piston forces fluid out the brake port to the brake assembly.

When brake pressure starts to build up, the main system inlet port is opened and fluid under pressure enters the cylinder in metered amounts to multiply the force exerted on the master cylinder piston. When force on the brake pedal is held steady, brake line pressure, system pressure balance, and the system inlet port are closed.

When foot pedal force is released, the master cylinder piston spring retracts the piston and brake line pressure is depleted through the passage opened between the two chambers. Fluid from the return side is also free to enter the brake assembly side of the master cylinder to compensate for loss of fluid through leakage or to supply additional fluid needed in the brake side chamber due to lining wear.

The power boost type system discussed and illustrated in the *AMH 3 & 2 Rate Training Manual* is similar to the brake system found on the A-7A; therefore, no further coverage is provided in this chapter.

Power/Manual Type

The power/manual brake system is a power brake scheme that combines some of the features of the independent and the true power brake system. During normal operation the power/manual system functions as a true power system; that is, the pilot's foot pressure regulates the amount of main system hydraulic pressure being routed to the brake assembly. With no system pressure, the power/manual system operates like the independent brake system with the brake valve performing the function of the master cylinder and creating a flow of fluid pressure for manual control of the brakes.

The F-4 aircraft's power/manual brake system, illustrated in figure 7-3, provides an example of a typical power/manual system.

Braking action is available in four different ways with this aircraft brake system. In addition to the normal power actuation, a limited number of power applications is available from accumulator pressure in case of loss of normal hydraulic power. When all accumulator hydraulic pressure is expended, limited braking may still be accomplished through the foot pedals utilizing the power/manual valve as a master cylinder. A pneumatic emergency system, completely separated from the normal system, is also incorporated.

Operation

Normal braking is accomplished by metering hydraulic pressure from the utility hydraulic system to each brake through the brake control units. The brake control units (power/manual valves) are operated by toe pressure on the brake/rudder pedals. As this toe pressure is applied to the pedal, the plunger is forced against a sleeve and shuttle assembly within the brake control unit. This action positions the

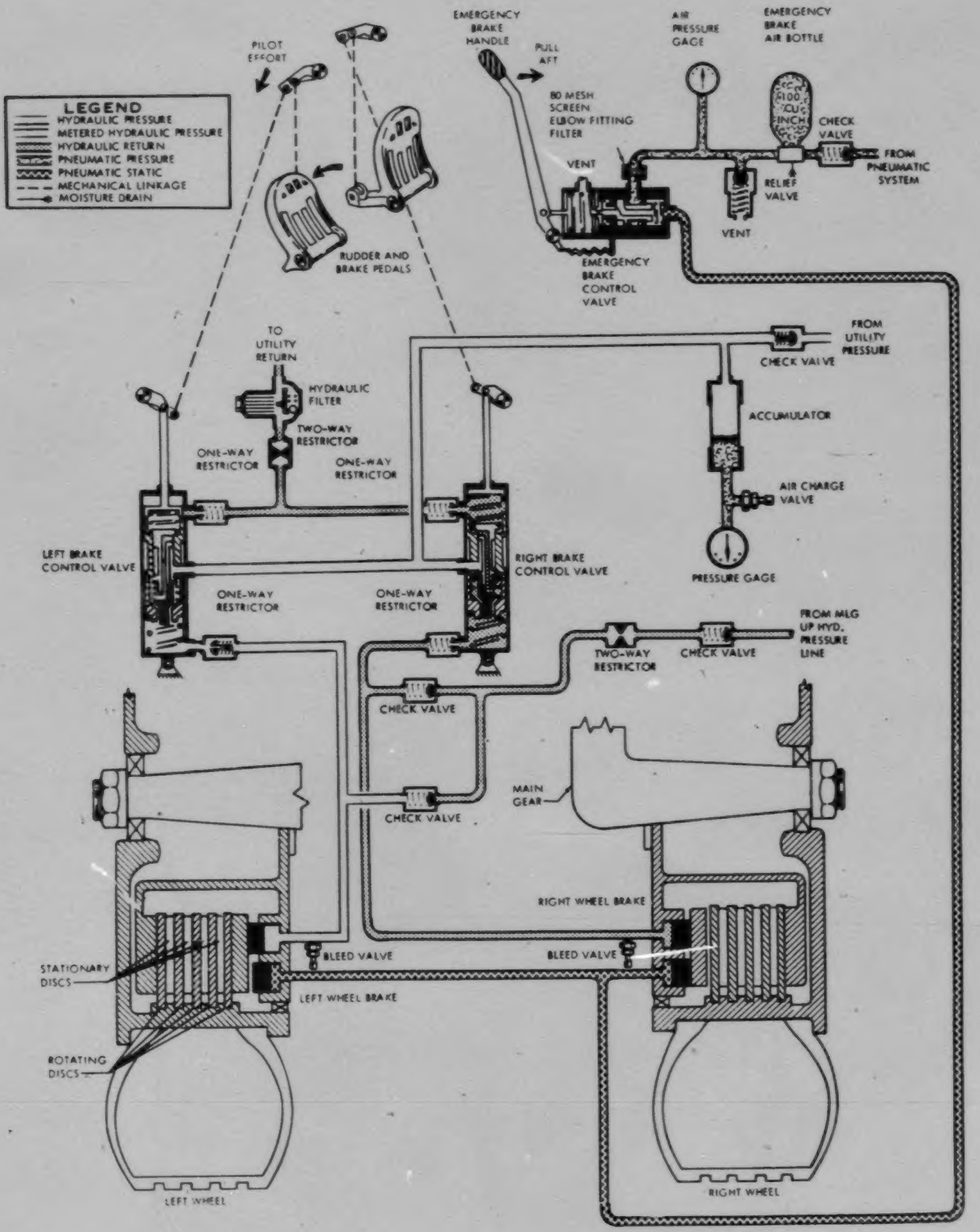
LEGEND
HYDRAULIC PRESSURE
METERED HYDRAULIC PRESSURE
HYDRAULIC RETURN
PNEUMATIC PRESSURE
PNEUMATIC STATIC
MECHANICAL LINKAGE
MOISTURE DRAIN
PILOT EFFORT
RUDDER AND BRAKE PEDALS
EMERGENCY BRAKE HANDLE
PULL AFT
80 MESH SCREEN ELBOW FITTING FILTER
VENT
EMERGENCY BRAKE CONTROL VALVE
AIR PRESSURE GAGE
EMERGENCY BRAKE AIR BOTTLE
100 CU INCH
CHECK VALVE
FROM PNEUMATIC SYSTEM
RELIEF VALVE
VENT
FROM UTILITY PRESSURE
CHECK VALVE
ACCUMULATOR
AIR CHARGE VALVE
PRESSURE GAGE
TO UTILITY RETURN
HYDRAULIC FILTER
TWO-WAY RESTRICTOR
ONE-WAY RESTRICTOR
ONE-WAY RESTRICTOR
LEFT BRAKE CONTROL VALVE
RIGHT BRAKE CONTROL VALVE
ONE-WAY RESTRICTOR
ONE-WAY RESTRICTOR
TWO-WAY RESTRICTOR
CHECK VALVE
FROM MLG UP HYD. PRESSURE LINE
CHECK VALVE
CHECK VALVE
MAIN GEAR
RIGHT WHEEL BRAKE
BLEED VALVE
BLEED VALVE
STATIONARY DISCS
LEFT WHEEL BRAKE
ROTATING DISCS
LEFT WHEEL
RIGHT WHEEL

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Figure 7-3.—F-4J/RF-4B power/manual brake system—schematic.

shuttle to allow metered flow of hydraulic fluid pressure from the utility hydraulic system pressure port, past the shuttle, through the poppet and seat to the brake pressure port, and out to the wheel brake assembly.

As soon as the pilot effort is released from the rudder/brake pedal, the utility hydraulic pressure port is blocked at the shuttle. Hydraulic fluid then flows back from the brake through the brake pressure port and is metered past the poppet and seat, through the shuttle, between the sleeve and spring guide, and out through the utility system return port.

In the event of a utility hydraulic system failure, the brakes may be applied by utilizing the fluid stored under pressure in a 25 cu in. accumulator that is fed into the brake system just upstream of the control units. There is enough fluid in the accumulator for 6 to 8 applications.

To actuate the brake emergency pneumatic system, the emergency brake valve handle in the pilot's cockpit is moved to provide an opening in the valve between the pneumatic system high pressure port and the brake pressure port. At the same time, the vent port is blocked, preventing the high pressure air from escaping to atmosphere. Air at 3,000 psi is then introduced from the accumulator to pneumatic pistons within the brake assembly.

When the pneumatic emergency brake handle is released, the spring-loaded mechanism within the valve actuates to block the pneumatic system high pressure port and the brake lines are vented to atmosphere through the valve vent port.

The brakes are automatically adjusted by bearing sleeves installed on the rod ends of the five hydraulic pistons in each wheel brake assembly. Spring washers installed on the sleeve permit the sleeve to move with the piston during brake applications and prevent the sleeve from retracting with the piston when the brakes are released. As the linings wear, the piston advances the sleeve, maintaining a constant running clearance.

Antispin operation is accomplished by teeing hydraulic pressure from the landing gear up lines through restrictors and check valves to the brake assemblies. Whenever the landing gear control handle is placed in the UP position and weight is off the wheels, pressure is routed to the brake assemblies, stopping wheel rotation prior to the wheels entering the wheel wells.

Antiskid control is available during normal braking. Left and right exciter rings and wheel speed sensors provide input signals to the antiskid control box which, in turn, controls the antiskid control valve. Pressure to the brake assemblies is controlled to provide maximum braking without skid.

Maintenance

Organizational maintenance of the wheel brake system of the F-4 consists of checking system operation, system adjustment, isolating malfunctions, and replacement and adjustment of system components. The checkout procedures in most Maintenance Instructions Manuals are provided for use during established inspections or for performing trouble analysis.

OPERATIONAL CHECK.–The aircraft is readied for an operational checkout by installing the landing gear downlocks, jacking the aircraft to provide proper ground clearance for the landing gear, and applying external electrical power. Placing the antiskid switch in the OFF position should illuminate the antiskid warning light. When the landing gear handle is moved to the UP position the antiskid light should go out. At this point, external hydraulic power is slowly applied to the utility system. The wheels should not rotate. Placing the landing gear handle to the DOWN position should illuminate the antiskid light and free the wheels to rotate. The brake pedals should be fully depressed to apply the brakes a minimum of 3 times.

The emergency system is operationally checked by pulling the emergency brake handle with external hydraulic and electrical power removed from the aircraft. The wheels should not rotate when the handle is pulled. Releasing the handle should immediately release the brakes. If any portion of the operational or functional test does not meet the results specified in the MIM, refer to the trouble analysis sheets for the brake system.

FUNCTIONAL TEST.–The aircraft is prepared for a complete functional checkout by installing the landing gear downlocks, jacking the aircraft to provide ground clearance for the landing gear, installing pressure gages in the wheel brake assembly's bleed ports, and applying external electrical and hydraulic power.

The antiskid switch is placed to the OFF position, and the antiskid warning light should illuminate. The landing gear handle is then moved to the UP position, causing the antiskid warning light to go out, and the gages on the brake assemblies should indicate 650-1,000 psi. Placing the landing gear handle to DOWN should illuminate the antiskid warning light, the brake gages should indicate a maximum of 75 psi, and the wheels should be free to rotate.

Electrical power is then removed from the aircraft, and the brake pedals are depressed and released several times to check braking action. A bubble protractor is placed on the brake pedals and adjusted to zero when the brakes are in the OFF position. When the brakes are fully depressed the protractor should indicate 30 ± 1°, and the hydraulic gages on the brake assemblies should indicate the same pressure as the external hydraulic power source.

The external hydraulic power is shut down, and system pressure is relieved by operating the rudder pedals. Brake accumulator action is checked by fully depressing the brake pedals several times and checking the brake assembly action. The emergency brake system is checked in the same manner as described for the operational checkout.

Figure 7-4 provides an illustration of the wheel brake assembly utilized on the later versions of the F-4.

The next steps of the functional checkout require that the wheel and tire assemblies be removed and hydraulic power reapplied. The brake pedals are fully depressed for approximately one minute, and each power plate is observed for hydraulic leakage.

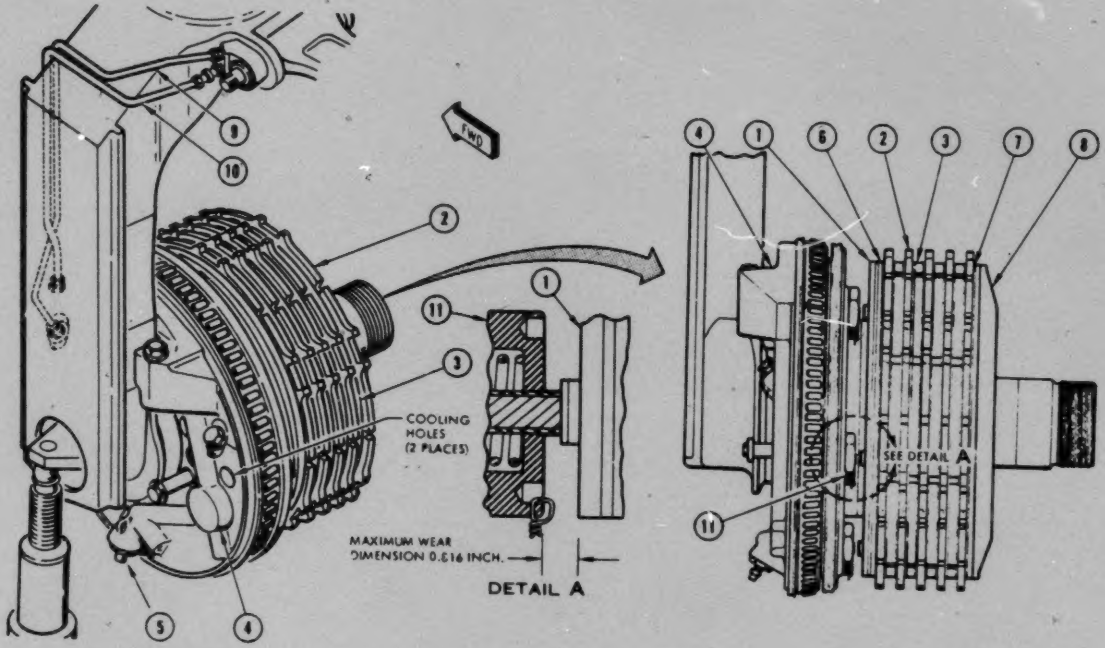
Lining wear may be checked by depressing the brake pedals and measuring the gap between the face of the primary disc assembly (1) and the screw thread insert (11). (See fig. 7-4.) Lining wear should not exceed 0.816 inch. Running clearance is checked by first applying the brake pedals until 1,200 psi is indicated on the gages installed in the brake bleed ports and measuring the distance between the primary disc and the face of the screw thread insert. Release the brakes and measure the distance again. Subtract this dimension from that obtained with the brakes applied to obtain the running clearance. Clearance should be 0.070 to 0.119.

BRAKE WEAR CHECK.–The brakes are checked for wear in the following manner:

1. Place a pressure gage assembly between the brake assembly hydraulic port and the hydraulic line assembly (10) (fig. 7-4.).
2. Apply external hydraulic power to the utility system.
3. Insert the brake wear gage into either brake cooling port in the power plate.
4. Depress the brake pedals until the gages indicate 1,200 psi at the brake port.
5. Push the wear gage indicator into contact with the primary disc insulation (6). The indicator should not be flush with or below the face of the locating sleeve.
6. Remove the brake wear gage. Repeat the same procedure at the adjacent brake cooling port.
7. Bleed brakes following removal of gage assemblies. The complete brake assembly must be inspected for hydraulic leaks.

EMERGENCY SYSTEM CONTAMINATION CHECK.–The emergency system is checked for contamination by removing the plug from the unused pneumatic pressure port on the brake assembly, positioning a clean white cloth adjacent to the opening, and slowly pulling the emergency brake control handle, allowing airflow through the system for approximately 5 seconds. There should be no evidence of combustible contaminants on the cloth. If the system is contaminated, the emergency brake pneumatic lines from the brake control valve to the brake assembly must be flushed with a suitable solvent and purged for a minimum of 15 minutes with heated nitrogen.

BLEEDING PROCEDURE.–As there is only a small displacement of hydraulic fluid contained in the brake units during operation, it is essential that the bleeding procedures outlined in the MIM be followed to relieve any trapped air within the system that might affect system operation.



1. Primary disc assembly.
2. Rotors.
3. Stators.
4. Power plate assembly.
5. Bleed valve.
6. Primary disc lining face.
7. Secondary disc insulation.
8. Secondary disc assembly.
9. Pneumatic pressure line.
10. Hydraulic pressure line.
11. Screw thread insert (5 each).

216.83

Figure 7-4.–Wheel brake (F-4J/F-4B 157342 and up).

Prior to commencing the bleed procedure, ensure that all landing gear down locks are installed and the utility hydraulic system reservoir is full and maintained full throughout the bleeding procedure. Remove the dust cover screw from the wheel brake bleed valves and attach bleeder hoses. Position the opposite ends of the bleeder hoses in a clean container with enough hydraulic fluid in the bottom of the container to submerge the end of the hoses. Bleed the antispin portion of the brake system (fig. 7-3) as follows:

1. Depress the main landing gear scissor switches.
2. Apply external electrical power.
3. Place the landing gear control handle to the UP position.
4. Apply external hydraulic power to the aircraft utility system and open the bleed valves on the brake assemblies until a clear steady stream of fluid, free of air bubbles, flows from the bleeder hoses.
5. Close bleed valves, placing the landing gear control handle to the DOWN position, remove the shims holding the landing gear scissor switches depressed, and remove electrical power.

The second stage of bleeding consists of depressing the brake pedals approximately 5 to 7 degrees of pedal travel to operate the power portion of the brake system. Open the bleeder valves to permit a fluid flow from the bleeder hoses until the fluid flow is bubble free. Ensure that the utility reservoir is full and repeat this procedure a minimum of three times to ensure that all entrapped air is cleared from the brake control units to the brakes. When it is determined that the power portion is free from air, close the bleed valves, release the brake pedals, and shut down the external hydraulic power.

The third stage of the bleeding procedure is necessary to ensure that all entrapped air is removed in the lines from the brake accumulator to the brake assemblies. Relieve utility hydraulic system pressure by operating the rudder pedals. Depress the brake pedals 5 to 7 degrees of pedal travel and open bleed valves. Close the bleed valves when fluid flow stops. Service the accumulator and apply external hydraulic pressure until the accumulator pressure stabilizes at 3,000 ± 100 psi. Secure external hydraulic pressure and repeat this bleed procedure until the brake accumulator portion of the brake system is free from air.

When all three stages of bleeding have been completed, tighten the bleed valves, remove the bleeder hoses, and safety the bleed valves with lockwire. Remove external electrical and hydraulic power sources, service the utility system reservoir as required, and perform a functional test to verify power system operation.

TROUBLE ANALYSIS.–Trouble analysis provides maintenance personnel with a means to logically pursue a trouble to a satisfactory solution by the process of elimination. The symptom is defined in tabular form with a remedy for each symptom, as shown in tables 7-2 and 7-3.

Table 7-2 relates to checkout procedures by direct reference, and table 7-3 relates to discrepancies occurring in an operational environment (in-flight or ground operations). Each table provides a remedy for each symptom. When the remedy is as simple as replacing a component or making an adjustment, this will be so stated. When the remedy requires further analysis, the entry in the REMEDY column will be a reference to an applicable paragraph and/or figure in the aircraft Maintenance Instructions Manual, or to some other manual.

Each trouble analysis procedure provides preliminary data, such as tools and equipment, manpower requirements, materials, etc. Table 7-4 illustrates a portion of the analysis procedures used in isolating a brake system malfunction on the F-4. The procedure contains a NO-YES column to direct the maintenanceman through a logical series of steps to isolate the malfunction.

When the requirements of a step are satisfactory, refer to the YES column and proceed to and perform the referenced step. When the requirements of a step are not satisfactory, refer to the NO column and perform the referenced step. This method is used until the malfunction is isolated and corrected. The original functional or operational checkout must be performed to ensure that the malfunction has been corrected.

Utilization of the troubleshooting charts/trouble analysis sheets and the system schematics provided in the Maintenance Instructions Manual is a prerequisite to keeping troubleshooting time at a minimum.

BRAKE SYSTEM COMPONENTS

Components of brake systems are, for the most part, not peculiar to any one system. A given component will vary in shape, size, capacity, and manner of operation, depending upon the manufacturer, but the function remains the same. In this section some of the more common brake system components are discussed, together with maintenance relative thereto.

INDEPENDENT SYSTEM RESERVOIR

The brake reservoir in the A-4 (fig. 7-5) is a small cylindrical tank installed in the nose section of the aircraft. It is a welded assembly which contains a filler port, manifold, filter assembly, vent, and a low level sight gage. The opening in the vent tube, the bottom of the manifold, and the bottom of the expansion tube (routed outside of the tank and entering the manifold at the top) are all on the same horizontal plane.

Table 7-2.–Example of checkout procedure trouble analysis sheet (F-4 brake system)

REFERENCE	SYMPTOM	REMEDY
Operational Checkout Paragraph 5-20.		
Step d	Anti-skid warning light fails to illuminate.	Replace warning light bulbs.
Step e	Warning light does not go out.	Refer to Paragraph 5-28A.
Step g	Wheel brake(s) inoperative during anti-spin operation.	Refer to Paragraph 5-52.
Step h	Anti-skid warning light fails to illuminate.	Refer to Paragraph 5-28A.
Step i	Wheel brake(s) will not release.	Refer to Paragraph 5-44.
Step j	Wheel brake(s) inoperative during normal operation.	Refer to Paragraph 5-40.
Step k	Wheel brake(s) will not release during normal operation.	Refer to Paragraph 5-44.
Step n	Wheel brake(s) inoperative during emergency operation.	Refer to Paragraph 5-46.
Step o	Wheel brake(s) will not release during emergency operation.	Refer to Paragraph 5-50.
Functional Checkout Paragraph 5-24		
Step e (2)	Warning light fails to illuminate.	Replace warning light bulbs.
Step e (3)	Anti-spin pressure above 1000 psi.	Refer to Paragraph 5-55.
	Anti-spin pressure below 650 psi.	Refer to Paragraph 5-52.
	Wheels rotate.	Replace wheel brake assembly.
	Anti-skid warning light does not go out.	Refer to Paragraph 5-28A.
Step e (4)	Excessive anti-spin return pressure	1. Replace restrictor 201-RA1M3 if left brake is high and 201-RA1M5 if right brake is high. 2. Repair clogged or crimped line between brake and control valve. 3. Replace brake control valve.
	Anti-skid warning light fails to illuminate.	Refer to Paragraph 5-28A.
Step e (5)	Wheel will not rotate.	Replace wheel brake assembly.
Step f	Wheel brake(s) inoperative during normal operation.	Refer to Paragraph 5-40.
Step g	Wheel brake(s) will not release during normal operation.	Refer to Paragraph 5-44.
Step j	Incorrect brake pedal deflection angle.	Rig brake pedals.
	Insufficient brake pressure at one or both brakes.	Replace brake control valve.
Step n	Wheels rotate with pedals depressed.	1. Service wheel brake accumulator. 2. Inspect for air leaks and repair as required. 3. Replace pressure gage 201-M1M55. 4. Replace air charge valve 201-VA1M57. 5. Replace accumulator. 6. Replace check valve 201-VA1M54.
Step o	Wheel brake(s) inoperative during emergency operation.	Refer to Paragraph 5-46.
Step p	Wheel brake(s) will not release during emergency operation.	Refer to Paragraph 5-50.
Step t	Power plates leak.	Replace wheel brake assembly.
Step v (1)	Excessive lining wear.	Replace wheel brake assembly.
Step v (3)	Incorrect running clearance.	Replace wheel brake assembly.
Step w (1)	Excessive lining wear.	Replace wheel brake assembly.
Step w (4)	Incorrect running clearance.	Replace wheel brake assembly.
Step z	Rotors and stators have foreign particles or are damaged, cracked, or warped.	Replace wheel brake assembly.

Table 7-3.—Example of operational environment (flight) symptom trouble analysis sheet (F-4 brake system)

SYMPTOM	REMEDY
Brake action uneven with application of equal pedal pressure.	1. Check tire for proper pressure and tread wear. 2. Perform system rigging. 3. Perform a functional checkout.
Braking action delayed momentarily when brakes were applied.	Perform Wheel Brake Bleeding.
Brakes pulled to one side.	1. Perform Wheel Brake Bleeding. 2. Replace dragging wheel brake. 3. Perform a functional checkout. 4. Inspect wheel bearings for wear.
Steady loss of pedal pressure when brakes are applied.	1. Replace brake control valve. 2. Perform a functional checkout.
Brakes grab and chatter when pedals are firmly depressed and then released slightly.	1. Perform Wheel Brake Bleeding. 2. Check brake accumulator gage for proper pressure. Service accumulator as required. 3. On F-4J, 153071z THRU 153846ae, AND 153848ae THRU 153866ae AFTER AFC 414; ALSO F-4J 153847ae AND 153867ae AND UP, replace one-way restrictors 201-RA1M4 and 201-RA1M6. 4. Replace brake control valve. 5. Perform a functional checkout.
Brake pedals not parallel with rudder in neutral and brakes released.	1. Perform system rigging. 2. Replace brake control valves.
Pedals will not give differential braking.	Replace check valve 201-VA1M60 if only left brake gives differential braking. Replace check valve 201-VA1M59 if only right brake gives differential braking.
Wheel brake accumulator will not hold an air charge after servicing.	1. Replace air pressure gage 201-M1M55. 2. Replace air charge valve 201-VA1M57. 3. Replace accumulator.

The filter assembly is installed in the manifold and extends down into the reservoir. When the reservoir is being filled, hydraulic fluid passes from the port through the manifold and filter assembly into the reservoir. The air displaced by the fluid escapes through the expansion tube, and out through the manifold.

The hydraulic fluid leaves the reservoir through the hydraulic fluid supply line to the master brake cylinders. Should the fluid expand (due to heat), that portion of the fluid that rises above the bottom of the manifold will pass through the opening in the vent tube, and out through the vent line. A restrictor on the vent line prevents fluid from escaping during inverted flight.

Repair of this brake reservoir is limited to disassembly, cleaning, and replacement of high-usage parts from a cure-date repair kit. These high-usage parts consist of a new sight glass with its O-ring seal, washer, and retainer; a new filter, packing, and plug; and a new nameplate for the reservoir housing.

The reservoir is cleaned inside and out with Stoddard Solvent. A fiber brush may be used on threads. The interior should be dried with clean, dry compressed air from a regulated low pressure source.

Table 7-4.—Example of analysis procedures sheet (F-4 brake system)

5-40. NORMAL BRAKE INOPERATIVE AT ONE OR BOTH WHEELS. See Figure 5-6 or 5-7.

5-41. Tools and Equipment.

Hydraulic Pressure Gage (11, Figure 2-2)

5-42. Manpower Requirements.

a. Two men required.

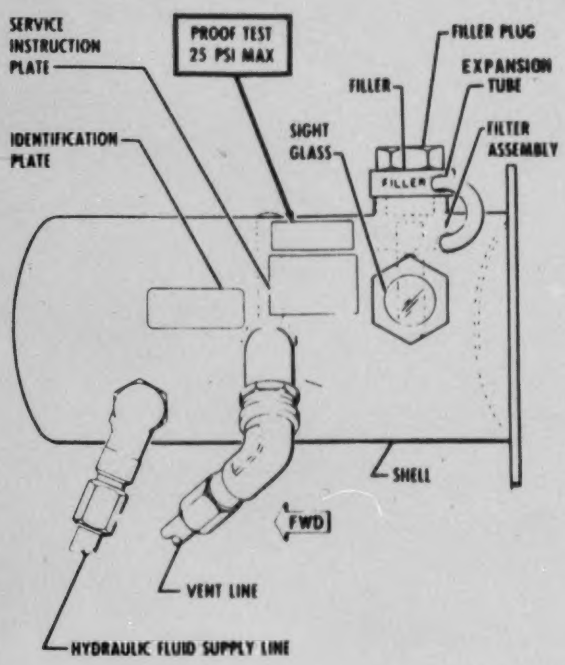
5-43. Procedure.

	NO	YES
a. Are both brakes inoperative?	g	b
b. Connect gage between check valve 201-VA1M54 and utility hydraulic system. Does pressure exist?	c	d
c. Perform a utility hydraulic system checkout. Refer to NAVAIR 01-245FDB-2-2.4.	-	-
d. Connect pressure gage between check valve 201-VA1M54 and accumulator 201-CA1M56 tee. Does pressure exist?	e	f
e. Replace check valve 201-VA1M54.	-	-
f. Repair/replace clogged or crimped line between check valve and control valve tee.	-	-
g. Is pressure present at inoperative brake with pedals depressed?	i	h
h. Replace wheel brake assembly.	-	-
i. Is pressure present at BRAKE port of brake control valve with pedals depressed?	m	j
j. On F-4B AND RF-4 151975t THRU 153115aa repair/replace clogged or crimped line between control valve and brake.	-	-
On F-4J AND RF-4B 157343ao AND UP, install pressure gage between check valve 201-VA1M60 and two-way restrictor 201-RA1M1. Does pressure exist when brake is depressed?	k	l
k. Repair/replace clogged or crimped line between control valve and brake.	-	-
l. Replace check valves 201-VA1M58 and 201-VA1M59 if left brake is inoperative.	-	-
Replace check valves 201-VA1M58 and 201-VA1M60 if right brake is operative.	-	-
m. Is pressure present at PRESS port of control valve?	n	o
n. Repair/replace clogged or crimped line between brake control valve and utility hydraulic system.	-	-
o. Replace brake control valve.	-	-

5-44. BRAKES WILL NOT RELEASE DURING NORMAL OPERATION. See Figure 5-6 or 5-7.

5-45. Procedure.

	NO	YES
a. Did malfunction occur at both wheel brakes?	i	b
b. Disconnect outlet line to filter 201-FA1M46. Did pressure release?	f	c
c. Repair/replace clogged or crimped line between filter and utility hydraulic system. Does malfunction still exist?	d	e
d. Return to service.	-	-
e. Troubleshoot utility hydraulic system. Refer to NAVAIR 01-245FDB-2-2.4.	-	-
f. Disconnect inlet line to filter. Did pressure release?	g	h
g. On F-4J 153071z THRU 153846ae, AND 153848ae THRU 153866ae BEFORE AFC 414, replace two-way restrictor 201-RA1M2. On F-4J 153071z THRU 153846ae, AND 153848ae THRU 153866ae AFTER AFC 414; ALSO F-4J 153847ae AND 153867ae AND UP AND RF-4B 157342ao AND UP, repair/replace clogged or crimped line between filter and tee.	-	-
h. Replace filter.	-	-
i. Disconnect line from RET port of brake control valve. Did brake release?	j	k
j. Repair/replace clogged or crimped line between control valve and tee.	-	-
k. Disconnect line from PRESS port of brake control valve. Did brake release?	l	m
l. Replace brake control valve.	-	-
m. Disconnect line from HYD port of wheel brake assembly. Did brake release?	n	o
n. Replace wheel brake assembly.	-	-
o. Repair/replace clogged or crimped line between wheel brake and brake control valve.	-	-



216.84

Figure 7-5.—Independent brake system reservoir.

After the reservoir is cleaned and the cure-date repair kit parts have been installed, a leakage test should be conducted. This is accomplished by connecting a source of 25 psi air to the filler port and applying pressure. The reservoir should then be submerged in a tank of water for a minimum of 2 minutes. No leakage should be apparent.

POWER BRAKE CYLINDERS

Power Brake Valve

The major function of the power brake valve is to release and regulate hydraulic fluid pressure from the aircraft hydraulic system to the brake.

The RA-5C is provided with two power brake valves. These valves have provisions to produce an artificial "feel" so that the pilot experiences the feeling of a conventional brake system. With 3,000 psi system pressure available, application of the brake pedal depresses the valve lever which, in turn, moves a plunger acting against a spring. As the spring is compressed, the slide is moved permitting a fluid flow between PRESS and BRAKE ports with the RETURN ports blocked off. Figure 7-6 illustrates a power brake valve.

As the pressure increases in the brake and brake lines, pressure also increases in a chamber housing a spring at the rear of the slide. With the aid of this spring and pressure, the slide is repositioned to meter a maximum of 2,300 psi hydraulic pressure to the brakes. The valve provides differential pressure at the wheel in proportion to the degree that the pedals are depressed. After the brakes are applied and held, there is no further flow from the valve. The PRESS and RETURN ports are now blocked off, causing this no-flow condition. When the brake pedal is released, it allows the slide to be repositioned by spring pressure and aligns the BRAKE and RETURN ports.

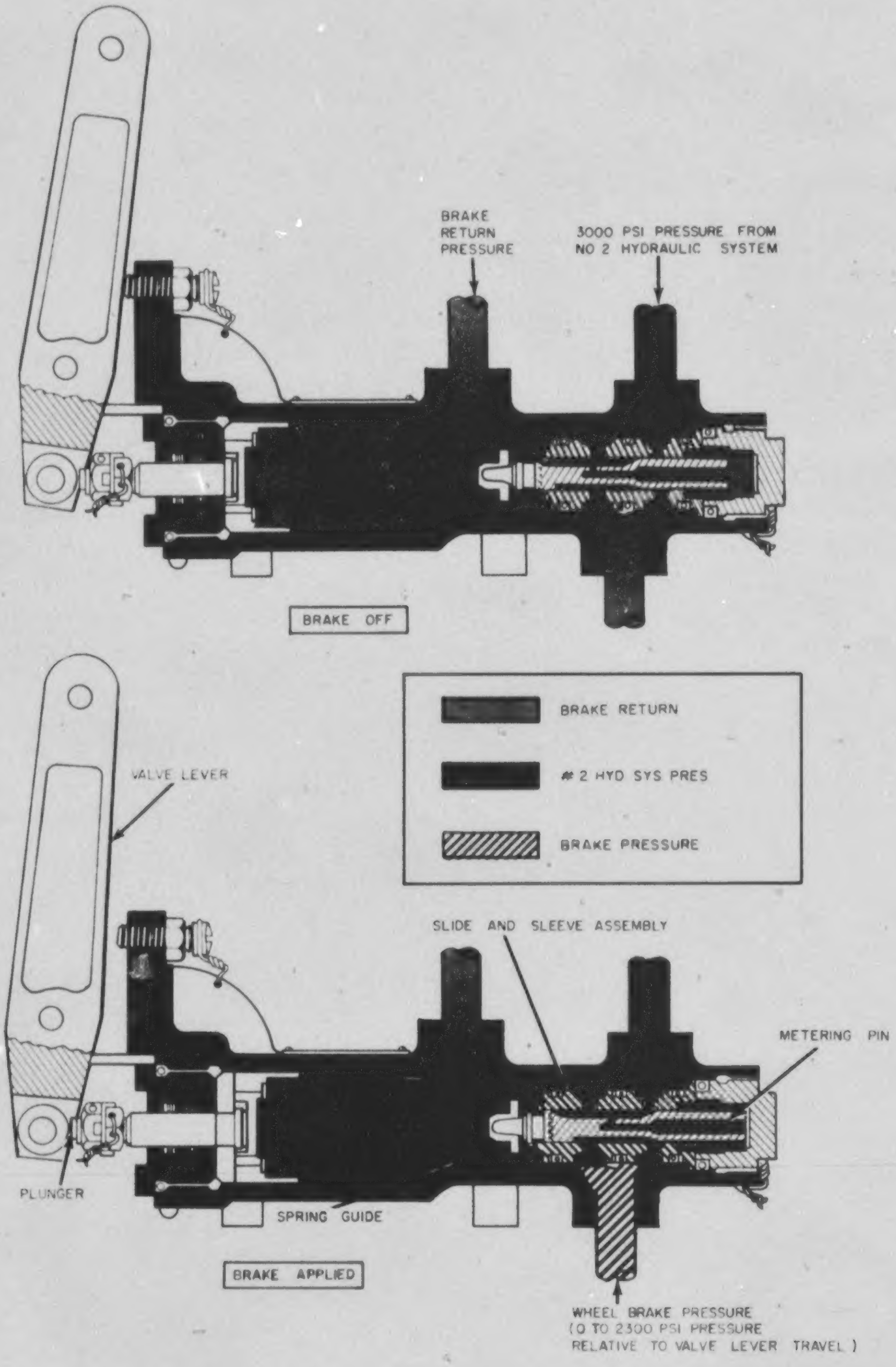
The brake assembly retractor plate moves the annular piston to the OFF position when the pressure is released. This forces hydraulic fluid in the lower brake lines back through the valve and to the reservoir through the brake system return lines.

Maintenance

Maintenance of these valves by Organizational level activities is limited to removal and replacement. After installation, the valves must be rigged and then an operational check made of the brake system in accordance with the Maintenance Instructions Manual.

Repair of the brake control valve consists of disassembly, cleaning, inspection, repair and replacement of parts, reassembly, and testing.

DISASSEMBLY.—Perform the disassembly in a clean working area, and as parts are removed, place them in a clean container for protection against dirt and damage. If the valve is to be disassembled for a considerable length of time, the parts should be protected from moisture. Note the method of lockwiring for reference during the reassembly process. The end cap and plunger assembly are removed as a unit, then disassembled for inspection, cleaning, and replacement of sealing devices. The opposite


BRAKE RETURN PRESSURE
3000 PSI PRESSURE FROM NO 2 HYDRAULIC SYSTEM
BRAKE OFF
BRAKE RETURN
# 2 HYD SYS PRES
BRAKE PRESSURE
VALVE LEVER
SLIDE AND SLEEVE ASSEMBLY
METERING PIN
PLUNGER
SPRING GUIDE
BRAKE APPLIED
WHEEL BRAKE PRESSURE (0 TO 2300 PSI PRESSURE RELATIVE TO VALVE LEVER TRAVEL)

216.85

Figure 7-6.—Power brake valve.

end cap is removed and the slide and sleeve assembly removed as a unit for disassembly.

CLEANING.–Parts are cleaned utilizing P-D-680 cleaning solvent. Except for the slide and sleeve, stubborn accumulations of dirt may be removed with a stiff bristle nonmetallic brush moistened in cleaning solvent. Dry all parts with low pressure, dry, filtered air.

NOTE: The slide and sleeve assembly are precision lapped parts. They must be kept together as a matched set, and extra care should be taken to prevent damage during maintenance.

INSPECTION.–Using a strong light and preferably some magnification, inspect all parts for scoring, nicks, cracks, burrs, excessive wear, corrosion, or other damage. Carefully examine all packing grooves and lands for burrs and other damage. The chrome plating of the plunger should be inspected for blisters, pinholes, flaking, or other damage, and plating should be continuous. The sliding surfaces of the slide and sleeve should be free from scratches, burrs, or nicks. Inspect the seating edges of the slide for sharpness and freedom from nicks and burrs. Any damage to the slide and sleeve will necessitate replacement of both parts of the matched assembly. The holes in the valve actuating lever are checked for elongation, and the roller that makes contact with the plunger is checked for smoothness and freedom from nicks and flat spots. Springs are tested for free length and test length versus test load in accordance with the spring data table provided in the 03 Manual.

REASSEMBLY.–Prior to reassembly, all internal parts are immersed in filtered, clean hydraulic fluid and assembled while still wet. Reassembly is accomplished in the reverse order of disassembly. Upon completion of reassembly the lever back stop adjustment screw is adjusted to the dimensions indicated in figure 7-7.

TESTING.–Figure 7-7 illustrates the operational test setup utilized to accomplish the variety of tests required to verify that the valve is ready for issue. A test stand capable of supplying hydraulic pressure from 0 to 4,500 psig pressure is required. Air is bled from the valve, and testing is conducted in accordance with the test procedures table provided in the Maintenance Instructions Manual and/or 03 Manual. Table 7-5 illustrates a portion of the test procedures that must be performed. Test includes proof test, static pressure test, pressure drop test for internal leakage, and a complete operational test to verify power operation and adjustment. A testing troubleshooting table is provided in the Intermediate Repair section of most MIMs and 03 manuals to assist in isolating causes for malfunctions that result from repair action.

After testing, the valve is filled with preservative hydraulic fluid, Mil-H-6083, and all ports are plugged. The lever back stop adjustment screw, the plunger end cap, and the

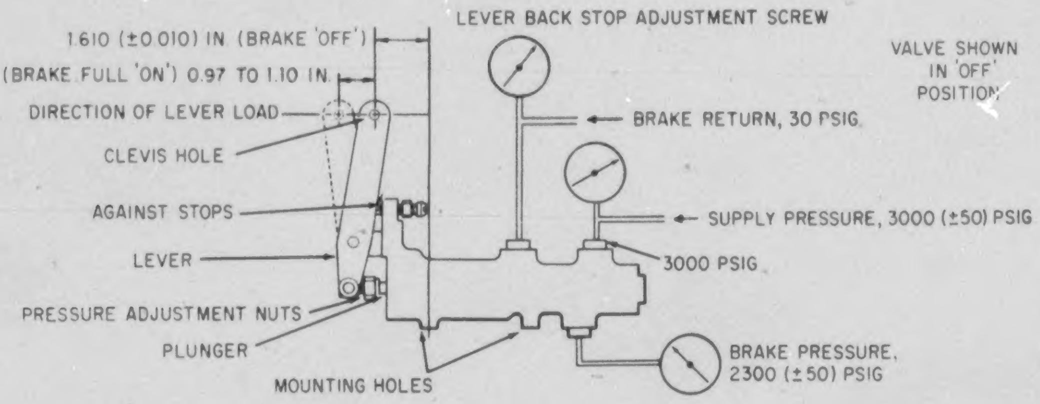

LEVER BACK STOP ADJUSTMENT SCREW
1.610 (±0.010) IN. (BRAKE 'OFF')
(BRAKE FULL 'ON') 0.97 TO 1.10 IN.
VALVE SHOWN IN 'OFF' POSITION
DIRECTION OF LEVER LOAD
BRAKE RETURN, 30 PSIG
CLEVIS HOLE
AGAINST STOPS
SUPPLY PRESSURE, 3000 (±50) PSIG
LEVER
3000 PSIG
PRESSURE ADJUSTMENT NUTS
PLUNGER
BRAKE PRESSURE, 2300 (±50) PSIG
MOUNTING HOLES
216.86

Figure 7-7.–Operational test setup-power brake valve.

Table 7-5.–Testing procedures–power brake valve

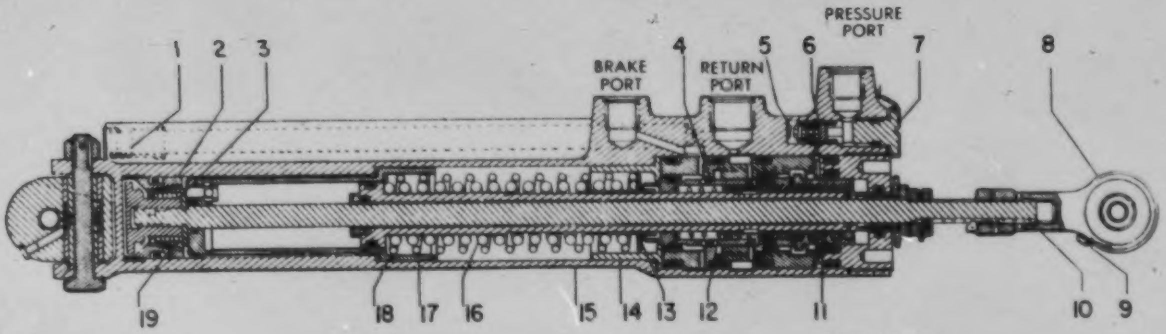
TEST NO.	TEST	PRESSURE	APPLY AT PORT	VALVE POSITION	PORTS BLOCKED	TIME *(Minutes)*	REQUIREMENTS
1	PROOF PRESSURE	4500	PRESSURE	OFF	BRAKE AND RETURN PORTS	3	CYCLE HANDLE SEVERAL TIMES. REQUIREMENT: THERE SHALL BE NO EVIDENCE OF EXTERNAL LEAKAGE, FAILURE, OR PERMANENT SET. *NOTE:* ALL CHAMBERS ARE PROOF TESTED BY THIS TEST.
2	LEVER POSITION	---	---	---	---	---	MEASURE DISTANCE PARALLEL TO CENTERLINE OF BODY FROM CENTERLINE OF MOUNTING HOLE NEAREST LEVER TO CENTERLINE OF CLEVIS HOLE IN LEVER, WITH VALVE IN **OFF** POSITION. SEE FIGURE 1. REQUIREMENT: THIS DIMENSION SHALL BE 1.610 (±0.010) INCH.
3a	OPERATION	3000	PRESSURE	AS REQUIRED	---	---	CONNECT BRAKE PORT TO GAGE PER FIGURE 1. BRAKE PRESSURE OBTAINED SHALL BE HELD FOR 30 SECONDS MINIMUM. OPERATION TESTS TO BE CONDUCTED CONTINUOUSLY IN INDICATED SEQUENCE. IF REQUIRED FORCE IS OVERSHOT, REDUCE TO ZERO AND START OVER. BRAKE PRESSURE MAY FLUCTUATE ±5 PERCENT OF NOMINAL PRESSURE AT RATE NOT TO EXCEED 10 CPM. THERE SHALL BE NO CHATTER, NO INDICATION OF BINDING OR STICKING, NO HESITATION OF PRESSURE AT BRAKE PORT, AND NO EXTERNAL LEAKAGE.
3b	INITIAL OPERATION	3000 AND 30	PRESSURE RETURN	REFER TO TEST 3a	BRAKE PORT WITH GAGE	---	ADJUST STOP SCREWS FOR PROPER LEVER TRAVEL AND ACTUATE LEVER SEVERAL TIMES. REQUIREMENT: BRAKE PRESSURE SHALL INCREASE AND DECREASE EACH CYCLE. THERE SHALL BE NO CHATTER OR ANY INDICATION OF BINDING OR STICKING.
3c	CRACKING PRESSURE *(Initial Metering)*	3000 AND 30	PRESSURE RETURN	REFER TO TEST 3a	BRAKE PORT WITH GAGE	---	APPLY A SLOWLY INCREASING FORCE AT CLEVIS HOLE OF THE LEVER IN A DIRECTION PARALLEL TO THE LONGITUDINAL CENTERLINE OF VALVE BODY UNTIL THE PRESSURE AT BRAKE PORT IS 40 PSIG. LEVER TRAVEL SHALL BE WITHIN THE LIMITS OF TABLE II.

216.87.1

end plug are lock-wired in the manner recorded prior to disassembly.

Power/Manual Brake Valve

The power/manual brake valve (fig. 7-8) derives its power for operation from system pressure when in the power-operated phase. This pressure is metered to the brakes in proportion to the amount of force applied to the brake pedals. The pedal force is counteracted by a differential surface area in the power/manual brake valve which is exposed to metered pressure. The metering valve shuts off when this pressure, multiplied by the differential surface area, equals the force applied to the pedals. When the brake pedals are depressed and the



1. Return plug.
2. Piston.
3. Piston head.
4. Spool and sleeve assembly.
5. Check spring.
6. Poppet.
7. Check valve body.
8. Rod end bearing.
9. Lubricator.
10. Rod end shaft.
11. Tube and plunger assembly.
12. Spool spring.
13. Power spring guide.
14. Stop.
15. Body.
16. Power spring.
17. Guide and check valve assembly.
18. Preload spring.
19. Piston spring.

216.87

Figure 7-8.--Power/manual brake valve.

valve extends, system pressure of 1,500 psi is applied to the brakes.

The power/manual brake valve operates as a master cylinder with the additional mechanical advantage of pedal forces when in the manual phase. The power/manual brake valve can be actuated a number of times without causing a shortage of fluid. The valve is automatically refilled from the normal system reservoir on the return stroke of the piston. Feel-sensitive springs are incorporated in the power/manual brake valve. The pilot's effort is transmitted through these springs, simulating an accustomed pedal motion.

There is no daily or routine maintenance required on the power/manual brake valve other than a wipedown of the reciprocating portion of the rod. There are, however, certain repairs that can be effected in case of valve malfunction. These include replacement of seals as required, and, in more serious cases, replacement of the tube, shaft, springs, or even the body.

Tests are not required on the individual valve parts. After disassembly, cleaning, inspection, repair or replacement, lubrication, and complete reassembly have been accomplished, a bench test should be performed to determine whether the unit satisfies the required minimum specifications.

The power/manual brake valves must be tested on a test bench and not while installed in the aircraft. The test bench used must be capable of supplying hydraulic fluid filtered through a 3-micron filter at a maximum pressure of 2,250 psi. During the test the room temperature should be 70° to 90°F and the fluid temperature 70° to 110°F.

The bench test is divided into two sections–i.e. the manual section and the power section. No particular sequence of performance of bench test is required, except that the proof pressure test of a section must precede the leakage test of that section. All air must be bled from the unit prior to testing.

PROOF PRESSURE TEST-MANUAL SECTION.—For this test the valve shaft must be harnessed in the midposition (1-inch plunger stroke), and the RETURN port must be plugged. Hydraulic pressure of 2,250 psi should then be applied to the BRAKE port. There should be no evidence of external leakage, permanent distortion, failure, or malfunction of any part of the valve.

PUMPING TEST.—To perform the pumping test, a reservoir should be connected to the RETURN port by means of 3/8-inch ID hose at least 24 inches long. Position the reservoir in such a way that the fluid is above (but not more than 6 inches) the RETURN port. Move the shaft to the fully actuated (2-inch plunger stroke) position and then cap the BRAKE port.

To commence the pumping test, cycle the valve rapidly. A rapid decrease in the length of successive pressure strokes should be noted. On each cycle the return stroke should be self-motivated.

LEAKAGE TEST-MANUAL SECTION.—Reposition the unit on the bench and harness the valve shaft in the midposition. With the RETURN and PRESSURE ports open, hydraulic pressure of 25 psi should be applied to the BRAKE port. There should be no evidence of external leakage, failure, or malfunction of any part of the valve. After the first minute, leakage at the RETURN port should not exceed 1 cu cm per minute in 2 minutes. If satisfactory at this stage, repeat the foregoing, using 500 psi at the BRAKE port.

With the valve in the relaxed position, apply static hydraulic pressure of 5 psi to the BRAKE and RETURN ports. There should be no external leakage, failure, or malfunction of any part of the valve. Repeat the foregoing with 200 psi of static hydraulic pressure.

PROOF PRESSURE TEST-POWER SECTION.—A pressure of 2,250 psi should be applied to the PRESSURE port with the BRAKE and RETURN ports open. Maintain the pressure for 2 minutes, observing meanwhile for evidence of external leakage, failure, or permanent set. This step should be performed twice.

OUTPUT PRESSURE TEST.—This test is performed in three stages. Hydraulic pressure of 1,500 psi is applied to the PRESSURE port and successive plunger loads of 47 pounds, 124 pounds, and 190 pounds applied. As a result of these applications, the pressure output readings at the BRAKE port should be 100 to 160 pounds on the first load, 660 to 750 on the second load, and 1,135 to 1,255 on the third load.

LEAKAGE TEST.—The leakage test for the power section requires 1,500 psi hydraulic pressure at the PRESSURE port with the BRAKE and RETURN ports open. With the valve shaft in the relaxed position, the combined leakage from the open ports should not exceed 25 cu cm per minute for the last 4 minutes of a 5-minute period. If the unit checks out, proceed to the next step.

With 1,500 psi still applied to the PRESSURE port, plug the BRAKE port, then extend the valve shaft to midpositon. Leakage from the RETURN port should not exceed 25 cu cm per minute for the last 4 minutes of a 5-minute period.

FLOW TEST.—To perform the flow test, hydraulic pressure of 1,500 psi should be applied to the PRESSURE port and the plunger operated to between 3/8 and 5/8 inch. Minimum flow at the BRAKE port should be 2 gpm, and there should be no evidence of chatter or instability.

After testing is completed, remove the valve from the test bench, flush it with hydraulic preservative oil, drip-drain the unit, and plug all ports. The body should be rubber-stamped with the cure date of the oldest O-ring or packing and tagged with the date of the test and the results.

MASTER BRAKE CYLINDER

Master brake cylinders provide a means of supplying hydraulic pressure to the main landing gear brake assemblies in the independent type system. Each master cylinder is installed on a support near each rudder pedal, with the piston rod attached directly (or indirectly through linkage) to the rudder pedal. The left-hand rudder pedal and master cylinder supply pressure only to the left-hand main landing gear brake assembly. The right-hand rudder pedal and master cylinder supply pressure only to the right-hand assembly.

Figure 7-9 is a cutaway drawing of the Gladden master brake cylinder which is used in the A-4 independent brake system.

Operation

The Gladden master brake cylinder consists of the following components: cylinder body, piston, piston rod, return springs, and a stop assembly. The piston contains an orifice to permit fluid to pass into the lower chamber of the cylinder. The piston rod and valve extend through the piston and stop assembly. The stop assembly passes through two coil springs, one of which is inserted into the other, thereby forcing the stop, piston rod, and piston to retract to a neutral position. This allows hydraulic fluid to enter the piston to fill the lower chamber. When the brake pedal is pivoted forward by toe pressure, the piston rod is forced down. This places the valve against the piston to close the orifice, thereby forcing the hydraulic fluid below the piston into the brake lines and into their respective brake assemblies. When toe pressure is relieved from the pedal, the spring forces the piston back to the neutral position.

Pumping the brake pedal results in a rapid repetition of the foregoing cycle, thereby forcing a greater amount of fluid to the brake assembly if required for stopping.

Maintenance

Maintenance of the master brake cylinder at the organizational level of maintenance consists of removal and replacement. Maintenance at the intermediate level consists of disassembly, cleaning, inspection, repair and replacement of seals and parts, lubrication, reassembly, and testing.

DISASSEMBLY.–Prior to disassembly, the Intermediate Repair section of the Maintenance Instructions Manual or the appropriate 03 Overhaul Instructions Manual should be studied to ascertain if all repair parts, material,

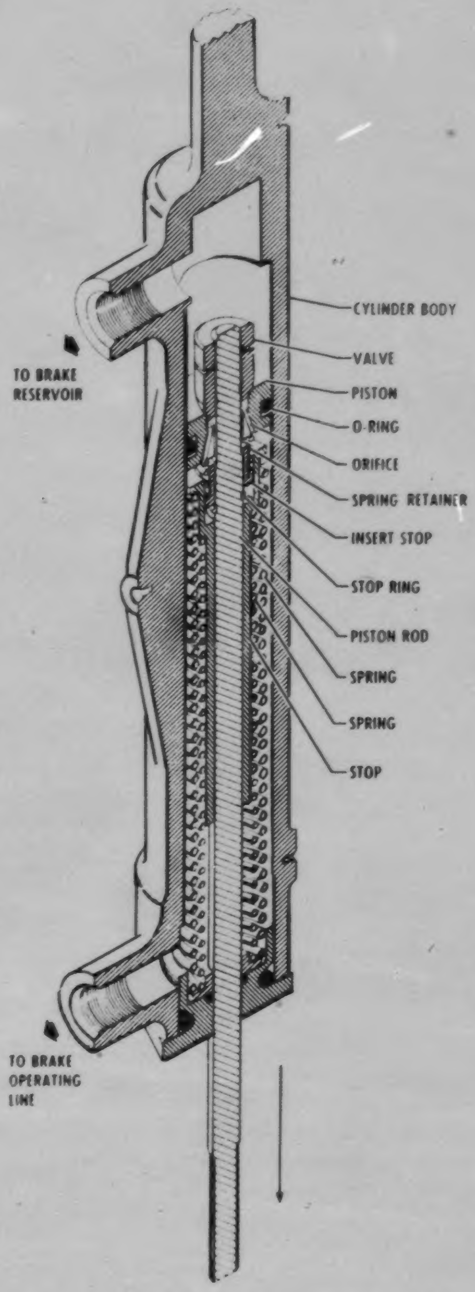


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Figure 7-9.—Master brake cylinder.

equipment, and facilities likely to be required during repair are available and ready for use.

WARNING: Prior to any removal, install an AN350-4 nut on the threaded end of the piston rod to bottom against the shaft bearing. This is done to eliminate the possibility of injury to personnel during disassembly because of spring preload.

The cylinder should be disassembled according to the procedures provided in the Repair section of the MIM and/or Overhaul Instructions Manual. Spring-loaded subassemblies should be placed in an arbor press or other device designed to restrain parts while tension is being relieved.

CLEANING.–Wash all reusable parts of the Gladden master brake cylinder with Cleaning Solvent P-D-680. A bristle brush should be used to loosen caked dirt from exterior surfaces and a piece of soft copper wire to remove obstructions from ports and passages. All parts should be thoroughly dried with a clean lint-free cloth or 20-psi compressed air.

INSPECTION.–The inspection of parts should be conducted under a strong light and preferably with a means of magnification. The following specific check should be made:

1. Check all parts for nicks, cracks, scratches, and corrosion.
2. Check threaded parts for crossed or otherwise damaged threads.
3. Check all packing grooves for surface defects that might cut packings during installation or cause sealing failures during operation.
4. Check the bearing on the suspension rod at the reservoir port end of the cylinder for freedom of rotation and evidence of flat spots.
5. Check all springs for specified load at given length. There should be no permanent set from test loading, and springs should not wobble when rolled across a flat surface.

REPAIR AND REPLACEMENT.–Minor nicks and scratches on metal parts may be polished out with crocus cloth (Federal Specification P-C-458C for steel parts, and P-C-451B for aluminum parts). During polishing, ensure that all dimensions are maintained within the specified limits and that seating and sealing surfaces are not damaged.

Damage to anodized finishes on aluminum parts may be repaired by applying a protective chemical film per Specification MIL-C-81706, Class IA, Form III.

WARNING: Chemical film materials are strongly oxidizing and are a fire hazard in contact with organic materials such as paint thinners. Do not store or mix surface treatment materials in containers previously containing flammable products. Rags contaminated with chemical film material should be burned as soon as practicable.

When replacing a suspension bearing, stake the new bearing at the original stake points on both sides of the body, using a 3/16-inch diameter ball in the staking tool. Verify the security of the bearing and inspect the area around the staking indentations for possible fractures.

Many parts for the repair of the Gladden master brake cylinder are provided in cure-date and overhaul kits. All other worn or damaged parts which cannot be reworked to meet inspection requirements should be replaced. Detail parts not provided in the kits may be available from bulk stock.

LUBRICATION.–A light coat of hydraulic fluid, Specification MIL-H-5606, or MIL-H-83282 should be applied to all sealing devices to facilitate reassembly. The recommended lubricant for the suspension rod end bearing is grease, Specification MIL-G-23827.

REASSEMBLY.–Reassemble all internal parts in reverse order of disassembly, using an arbor press or equivalent and an AN350-4 nut in order to facilitate assembly and to eliminate the possibility of personnel injury due to preload of springs.

TESTING.–The test equipment required includes a conventional hydraulic test bench capable of delivering test fluid to 4,500-psi pressure at room temperature plus the

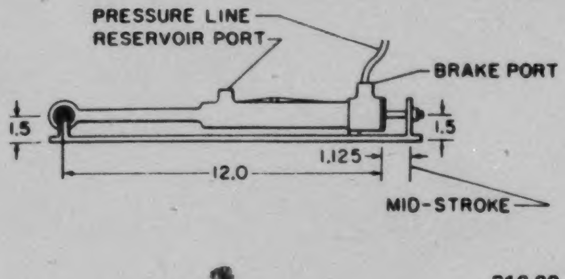

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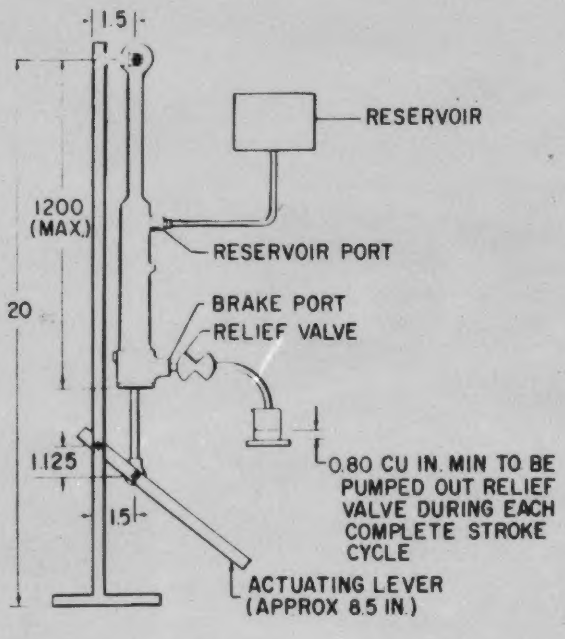
Figure 7-10.—Piston, valve, and brake chamber proof test setup diagram.

equipment illustrated in figures 7-10 and 7-11. The nominal extended length of the unit from the center of the end bearing to the end of the actuating rod is 15.31 inches.

To proof test the inlet chamber and perform a leakage test, apply first 5 psi, then 200 psi at the reservoir port with the brake port plugged. There should be no external leakage in 1 minute from either port.


1.5
RESERVOIR
1200 (MAX.)
RESERVOIR PORT
20
BRAKE PORT
RELIEF VALVE
1.125
1.5
0.80 CU IN. MIN TO BE PUMPED OUT RELIEF VALVE DURING EACH COMPLETE STROKE CYCLE
ACTUATING LEVER (APPROX 8.5 IN.)

216.90

Figure 7-11.—Rod packing, cylinder leakage, and pumping function test.

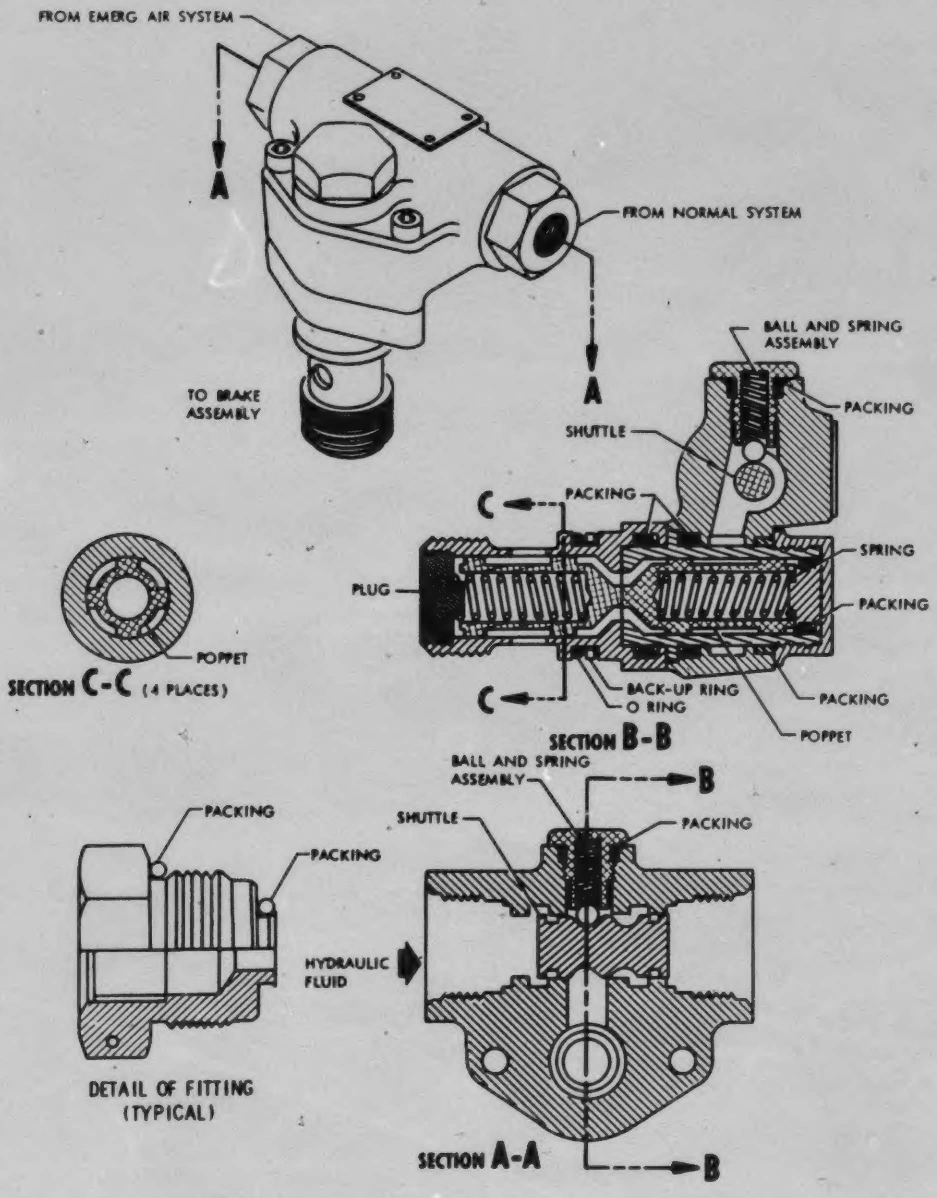
To perform the piston, valve, and brake chamber proof test, install the unit in the jig (fig. 7-10) and harness it at the midstroke position with 25-psi hydraulic pressure applied at the brake port. There should be no external leakage. Leakage at the reservoir port should not exceed 1 drop per minute in 2 minutes after a 1-minute waiting period. If the unit tests satisfactorily at this stage, the pressure should be increased to 2,000 psi. Again, there should be no external leakage, and leakage at the reservoir port should not exceed 1 drop per minute for 2 minutes after a 1-minute waiting period.

When the foregoing test is completed, the unit is ready to receive a rod packing, cycling leakage, and pumping function test. With the unit extended and installed in the actuating fixture (fig. 7-11), a reservoir should be connected to the reservoir port and a 200-to-400 psi relief valve should be connected to the brake port. Operation of the manual lever through five full strokes should pump hydraulic fluid through the relief valve. Leakage at the piston rod gland should not exceed 1 drop at this time. Not less than 0.75 cu in. of fluid should flow from the relief valve during any one complete stroke cycle of the manual lever.

There should be no evidence of binding at any time during these tests.

BRAKE SHUTTLE DISCONNECT VALVE

Shuttle valves are used in the hydraulic system to isolate one system or part of a system from another. In the brake system they may be used to separate the emergency system from the normal system as well as to separate the pilot's and copilot's brake valves or master cylinders pressure from each other. The brake shuttle and disconnect valve of the P-3 aircraft is shown in figure 7-12. The unit is made up of two halves. One of these halves screws into the brake assembly. The external portion of the valve contains a check valve and the shuttle valve. It is fastened to the brake-mounted half by two Allen-head bolts. A spring-loaded check valve in the shuttle half of the assembly prevents loss of fluid in the brake system when the two halves


FROM EMERG AIR SYSTEM
A
FROM NORMAL SYSTEM
TO BRAKE ASSEMBLY
A
BALL AND SPRING ASSEMBLY
PACKING
SHUTTLE
PACKING
C
SPRING
PLUG
PACKING
POPPET
SECTION C-C (4 PLACES)
C
BACK-UP RING
O RING
PACKING
POPPET
SECTION B-B
BALL AND SPRING ASSEMBLY
B
SHUTTLE
PACKING
PACKING
PACKING
HYDRAULIC FLUID
DETAIL OF FITTING (TYPICAL)
SECTION A-A
B

216.91

Figure 7-12.—Brake shuttle and disconnect valve.

are disconnected. When the two halves are reconnected, the poppet in the brake assembly half presses against the poppet half in the shuttle portion and opens the check valve.

Enclosed in the body is a sliding part called the shuttle. It is used to seal one of the two inlet ports. A shuttle seat is installed at each inlet port; and during operation, the shuttle is held against one of these seats, sealing off that port. These parts are held in the body by end caps. External leakage is prevented by an O-ring gasket at each end cap.

The shuttle may be one of four types—a sliding plunger (illustrated in fig. 7-12), a spring-loaded piston, a spring-loaded ball, or a spring-loaded poppet. In shuttle valves employing a shuttle spring, the shuttle is normally held against the emergency inlet port by the spring.

When a shuttle valve is in the normal operating position, fluid has a free flow from the normal system inlet port to the unit outlet port. The shuttle is seated against the emergency inlet port and is held there by the shuttle spring or by normal system pressure. The shuttle remains in this position until the emergency fluid, gas, or air is released under pressure by the emergency control valve. The application of emergency pressure at the emergency inlet ports forces the shuttle from the emergency inlet port seat to the normal system inlet port seat. The emergency pressure then has a free flow to the unit outlet port, but is prevented from entering the normal system by the shuttle.

Shuttle valve maintenance is generally limited to repairing leakage. External leakage may usually be repaired by tightening the end caps. If this does not stop excessive leakage, the end cap O-ring should be replaced.

Internal leakage can usually be repaired by removing and flushing the unit with clean hydraulic fluid. Excessive heating is a good indication of internal leakage through a shuttle valve. Excessive cycling of the emergency system pump is also an indication of a leaky shuttle valve.

After an emergency system has been operated, all emergency system pressure should be bled off as soon as possible and the normal system restored to operation.

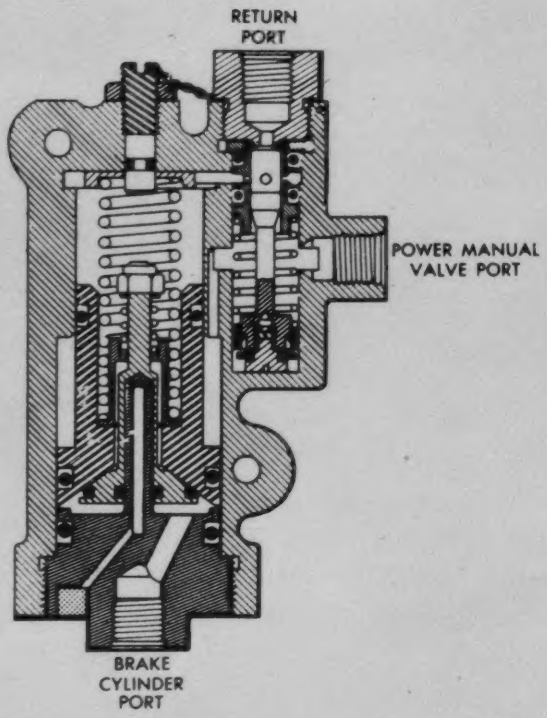


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Figure 7-13.—Automatic brake adjuster valve.

AUTOMATIC BRAKE ADJUSTER VALVE

Automatic brake adjuster valves (fig. 7-13), which hydraulically maintain brake running clearance, are installed in some aircraft. These valves eliminate the necessity for mechanical adjusters in the brake assemblies. Automatic adjuster valves also function to relieve excessive wheel brake pressure due to thermal expansion and bleed into the return line any air trapped in the wheel brakes. Brake adjusters (when incorporated) are located schematically between the brake control valves and the brake assemblies.

Operation

The operation of the brake adjuster valve is dependent on the output pressure of the power/manual brake valve regardless of the phase (power or manual) of the brake valve. With brake adjuster valve inlet pressures up to about 75 psi, the adjuster valve will produce a volumetric boost ratio of 2.5 to 1. Above 75 psi the ratio is 1 to 1.

The main function of the adjuster valve is to maintain a running brake clearance of 0.060 inch, ragardless of the amount of brake lining wear (0.400 inch maximum). This action of the adjuster valve results when the adjuster valve piston withdraws the same volume of hydraulic fluid from the brake assembly on every return stroke. The remaining fluid (approximately 10 cu cm) is ported through the return port to the main hydraulic reservoir. This return of the remaining fluid also assists in bleeding the brakes and lines of air.

A thermal relief feature is incorporated in the adjuster piston through a valve which is set to relieve at approximately 37 psi.

Maintenance

Tests are not required on the individual adjuster valve parts. After disassembly, cleaning, inspection, repair or replacement, and complete reassembly have been accomplished, a bench test is performed to determine whether the brake adjuster valve satisfies the required minimum specifications.

DISASSEMBLY.–The brake adjuster valve should be disassembled in accordance with instructions contained in the appropriate Overhaul Instructions Manual. Check the safety wiring before initiating disassembly in order to facilitate rewiring upon reassembly.

CLEANING.–Clean all parts except the nylon insert and O-rings with trichlorethylene. The insert and O-rings will normally be replaced upon each disassembly of the valve. Parts should be dried with dry, clean, filtered, compressed air.

WARNING: Do not inhale solvent vapors or direct compressed air against the skin.

INSPECTION.–Inspections should be performed under a strong light and with magnification. All threads should be inspected for crossed, filled, or stripped condition and internal threads for evidence of wear or damage as well. Inspect all parts for nicks, scratches, scoring, corrosion, or other apparent damage. Check all drilled passages for obstructions, and the filter for condition.

REPAIR OR PARTS REPLACEMENT.–Any part that is damaged or does not function properly should be replaced. During replacement and prior to actual reassembly, lightly coat all parts with hydraulic preservative fluid and assemble while wet.

REASSEMBLY.–Reassembly is essentially the reverse of disassembly. Precise directions for reassembly are also provided in the Overhaul Instructions Manual.

BENCH TEST.–The bench test consists of a series of tests–proof pressure, thermal crack, shuttle valve opening operation, shuttle valve closing operation, and leakage. These tests must be performed in the order listed on a test bench and not while installed in the aircraft. The test bench used must be capable of supplying hydraulic oil filtered through a 10-micron filter at a maximum pressure of 2,250 psi. The tests should be conducted at a room temperature of 70° to 90°F and a fluid temperature of 70° to 110°F. Prior to starting the test, all air should be bled from the unit. After testing has been completed, the valve should be removed from the bench, flushed with hydraulic preservative fluid, drip-drained, and the ports plugged. The cure date of the oldest sealing device should be rubber-stamped on the body of the valve and the unit tagged with the date and results of the test.

To perform the proof pressure test, apply a hydrostatic proof pressure of 2,250 psi to the RET. (return) port with the BRAKE and PMV (power/manual valve) ports interconnected. This pressure should be applied twice and held for a 2-minute period each time. There should be no evidence of external leakage, failure, distortion, or permanent set.

The thermal crack test is performed by applying pressure gradually to the BRAKE port with the RET. and PMV ports open, until the valve cracks. The residual pressure should not be less than 27 psi. Again, gradually increase pressure at the BRAKE port until the valve cracks. The cracking pressure should be between 30 and 37 psi. There should be no leakage from the PMV port.

NOTE: During piston travel a volume of fluid will be displaced through the PMV port. Only that portion of displaced fluid which exceeds 10 cu cm should be considered as leakage. No RET port fluid displacement should be considered leakage.

The foregoing completes the thermal crack test. In preparation for the shuttle valve opening operation test which follows, block residual pressure in the BRAKE port using a pressure gage as the plug.

With the RET. port open and BRAKE port capped, hand-pump hydraulic pressure should be gradually applied to the PMV port. There should be a simultaneous increase of BRAKE port pressure with PMV port pressure. At a pressure of 60 to 80 psi in the PMV port, pressure in the PMV port and BRAKE port should become equal. A gradual increase in PMV port pressure to 1,500 psi should result in a proportionate increase in the BRAKE port pressure. Any displacement at the RET. port should not be considered leakage during this phase of the bench test.

The shuttle valve closing operation test is commenced with 1,500 psi from the previous phase still applied to the PMV port. Reduce the pressure at the PMV port to 150 psi and then rapidly to 0. The closing operation is evidenced by the venting of hydraulic fluid from the RET. port as PMV pressure decreases below 20 psi to 0 psi.

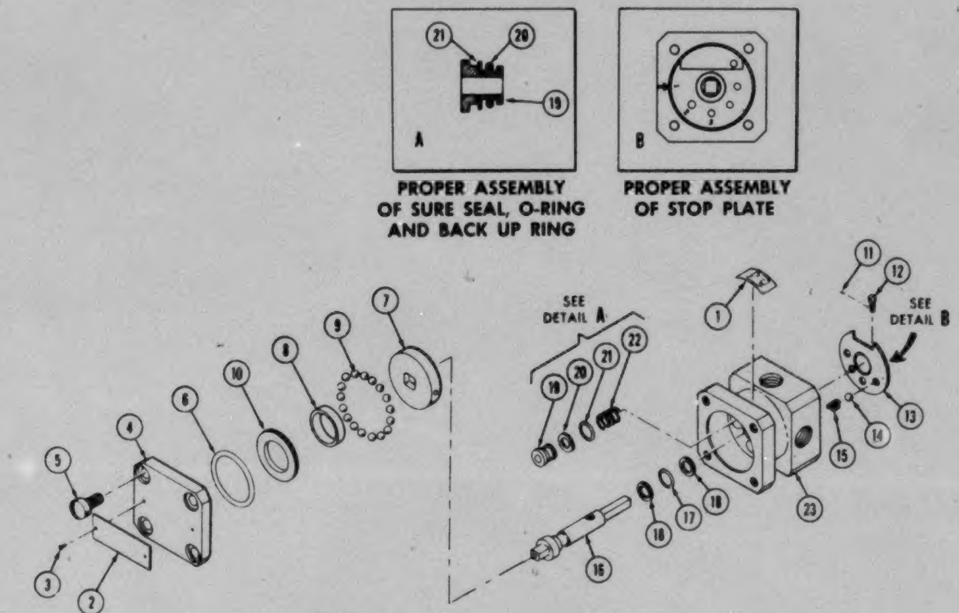
The final phase of the bench test is the test for leakage. This phase is started with 27 psi hydraulic pressure trapped in the BRAKE port. There should be no evidence of pressure decrease when measured over a period of 3 minutes. Continue the test with the BRAKE port capped and the RET. port of the valve in an upright attitude. Fill the RET. port cavity and a leakage measuring device with hydraulic fluid. Apply hand-pump hydraulic pressure of 30 to 37 psi to the PMV port. Leakage at the RET. port must not exceed 0.5 cu cm per minute. Immediately after application of pressure, measure the leakage for a 3-minute period. Disregard volume displacement due to shuttle valve transition if leakage is not in excess of 0.5 cu cm per minute. Increase the pressure to 125 psi and maintain for a 3-minute period. There should be no evidence of leakage. Further increase the pressure to 1,500 psi and maintain for another 3-minute period. There should still be no leakage.

BRAKE PRIORITY VALVE

The brake priority valve (fig. 7-2) is a part of the auxiliary brake system. It is installed between the brake selector valve and the pressure side of the power brake valves. A tee fitting connects the priority valve to both brake valves. When the brake selector valve is placed at the AUX TURN position, pressure in the accumulator is directed through the priority valve to the brake valves. The priority valve prevents the total accumulator capacity from being depleted during auxiliary brake operation. The priority valve is set to full flow at 1,285 psi and reseat at 1,085 psi. The action of the priority valve assures that enough accumulator pressure is retained to supply four full emergency applications by hand when the brake selector handle is pulled to the EMERG PULL position. Maintenance of the valve consists of removal and replacement.

BRAKE SELECTOR VALVE

The brake selector valve for the A-6A brake system, illustrated in figure 7-2, is a four-way, three-position, mechanically-actuated rotary valve. When the valve is in the normal position, the return flow only is directed through the valve. When the valve is in the auxiliary position, the pressure flow is from the accumulator through the selector valve to the brake control valve. When the valve is in the emergency position, hydraulic power for the system comes from the brake accumulator. The pressure bypasses all components and flows directly to the wheels. The three positions of the valve are indexed with the brake handle in the cockpit. The handle is connected to the valve by a cable and pulley arrangement.


21
20
19
A
PROPER ASSEMBLY OF SURE SEAL, O-RING AND BACK UP RING
B
PROPER ASSEMBLY OF STOP PLATE
SEE DETAIL A
SEE DETAIL B
1
2
3
4
5
6
7
8
9
10
11
12
13
14
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16
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18
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22
23

1. Decal.
2. Nameplate.
3. Drive screw.
4. Retainer plate.
5. Machine screw.
6. O-ring.
7. Shear plate assembly.
8. Ball retainer.
9. Balls.
10. Bearing plate.
11. Threadlock.
12. Lock screw.
13. Stop plate.
14. Ball.
15. Detent spring.
16. Actuating shaft.
17. O-ring.
18. Backup ring.
19. Sure seal.
20. O-ring.
21. Backup ring.
22. Seal spring.
23. Body assembly.

216.93

Figure 7-14.—Brake selector valve—exploded view (A-6A).

Maintenance

Repair of the brake selector valve at the intermediate level of maintenance is limited to replacement of cure-date items and the replacement of parts listed under Spares and Replacement Parts Data in the Intermediate Maintenance section of the Maintenance Instructions Manual.

Figure 7-14 illustrates an exploded view of the selector valve. Observe the arrangement in which the machine screws are lockwired to facilitate reassembly. The valve is disassembled and all parts are cleaned in drycleaning solvent and dried thoroughly using low-pressure, moisture-free compressed air, or a lint-free clean cloth. All parts are inspected for scratches, cracks, scoring, burrs, nicks, excessive wear, and distortion. If any part other than those listed in the Spare and Repair Parts Data is faulty, the component must be tagged to show the fault and forwarded to the next higher level of maintenance.

Replace all sealing devices and worn or damaged parts. Apply a light coating of hydraulic fluid on all O-rings, backup rings, sure seals, and wear surfaces prior to reassembly. Note the proper assembly of the sure seal, O-ring and backup ring and the proper assembly of the stop plate, as illustrated in figure 7-14. Reassembly is essentially the reverse order of disassembly. Steps that require quality assurance verification are so indicated in the Maintenance Instructions Manual by being underlined. The four machine screws that hold the selector valve assembly together must be tightened and properly lockwired.

The repaired valve must be bench-tested to verify its RFI condition. The hydraulic fluid used to test the valve must be continuously filtered by a 15-micron (or less) absolute, nonbypass filter upstream of the valve. The test stand fluid should be allowed to reach an operating temperature of 70 to 110°F prior to beginning the testing. The valve must pass a proof test, static pressure test, actuation (operational) test, and leakage tests. During the actuation test the amount of torque required to operate the valve to any position should not exceed 40 inch-pounds with 3,000 psi applied to the pressure port. The requirements for each test are specified in the Intermediate Repair section of the MIM.

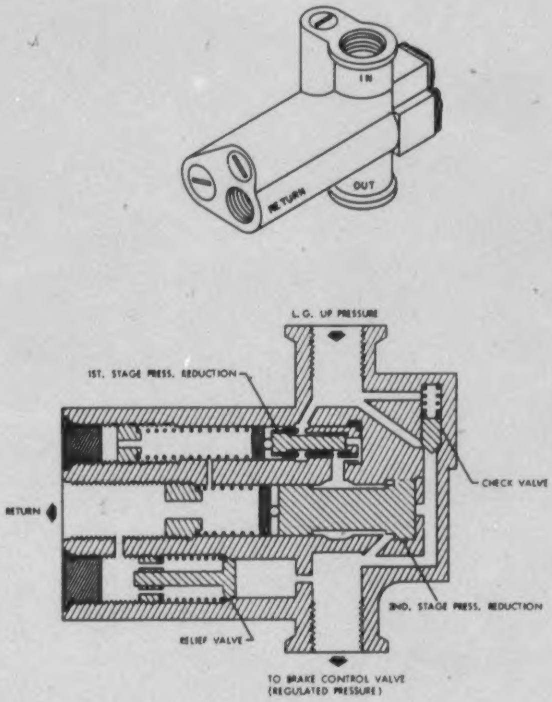

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Figure 7-15.—Brake in-flight pressure regulator valve (P-3A).

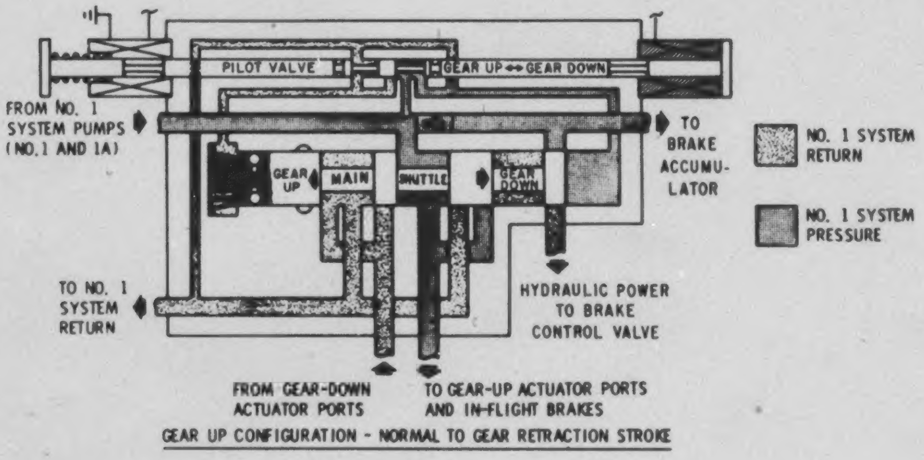
BRAKE IN-FLIGHT PRESSURE REGULATOR VALVE (ANTI-SPIN)

Several aircraft braking systems incorporate an in-flight pressure regulator valve which regulates pressure to the brake assembly to stop wheel rotation on takeoff when the landing gear handle has been moved to the UP position. The in-flight pressure regulator utilized in the P-3A is illustrated in figure 7-15. This valve will stop main gear wheel rotation in from 1 to 4 seconds after the landing gear control handle is moved to the UP position. The valve consists of three sections: the pressure reducing section, the relief valve section, and the check valve section.

The pressure reducing section reduces No. 1 hydraulic system pressure from 3,000 psi to between 90 and 105 psi. The relief valve section provides relief from the reduced pressure side of the valve if pressure cannot be maintained between 90 and 105 psi. Relief cracking pressure begins at 115 ± 5 psi. The relief valve will be fully open at 135 psi.

The check valve section allows immediate return flow to the system return through the landing gear up lines when the landing gear control lever is placed in the DOWN position or when the selector valve shuttle (landing gear) returns to its neutral position. The valve also provides a passage for normal return flow to the No. 1 return system when the landing gear lever is in the DOWN position and braking occurs.

Organizational maintenance of the valve consists of removal and replacement. Miscellaenous repair and parts replacement and cure-date seal replacement are accomplished at the intermediate and depot levels of maintenance.


PILOT VALVE
GEAR UP ↔ GEAR DOWN
FROM NO. 1 SYSTEM PUMPS (NO.1 AND 1A)
TO BRAKE ACCUMU-LATOR
NO. 1 SYSTEM RETURN
NO. 1 SYSTEM PRESSURE
GEAR UP
MAIN
SHUTTLE
GEAR DOWN
TO NO. 1 SYSTEM RETURN
HYDRAULIC POWER TO BRAKE CONTROL VALVE
FROM GEAR-DOWN ACTUATOR PORTS
TO GEAR-UP ACTUATOR PORTS AND IN-FLIGHT BRAKES
GEAR UP CONFIGURATION - NORMAL TO GEAR RETRACTION STROKE

216.95

Figure 7-16.—Landing gear selector and brake shutoff valve schematic (P-3A).

BRAKE BYPASS VALVES

Aircraft braking systems utilizing hydraulic fuses to prevent loss of excessive hydraulic fluid in the case of brake malfunction generally must bypass the fuse to bleed the brakes. The P-3 aircraft utilizes a bypass valve incorporated into the brake manifold to direct fluid around the fuse for ground servicing and bleeding, and provides a means of applying back pressure to the fuse for resetting. The valve consists of a valve body and a needle valve. Opening the needle valve diverts fluid around the fuse. The needle valve is normally lockwired in the closed position.

LANDING GEAR SELECTOR AND BRAKE SHUTOFF VALVE

The landing gear selector valve for the P-3, illustrated in figure 7-16, features an integral tandem shutoff valve which is used to close the pressure inlet line to the power brake valve during landing gear retraction. The valve body contains a pilot valve operated by two solenoids spring-loaded to the neutral position. The pilot valve directs fluid to reposition the shuttle valve which, in turn, directs fluid through the valve's six ports.

When the landing gear handle is placed in the DOWN position, the pilot spool positions the main shuttle to allow fluid to flow from the pressure port through the down port and brake in and out ports. Fluid in the system returns through the up port and out the return port.

When the landing gear handle is placed in the UP position, the pilot spool then positions the shuttle to allow fluid flow through the pressure port to the gear up actuator ports and the inflight pressure regulator. Pressure also unseats a check valve within the selector valve and flows out the brake in port. When the landing gear is fully retracted, the selector valve is deenergized by the action of the uplock switches, and the spring-loaded pilot and shuttle valves are returned to the neutral position. This shuts off all hydraulic pressure to the landing gear and in-flight brake system and ports the up and down landing gear lines to return.

EMERGENCY BRAKE ACTUATING (AIR MODULATOR) VALVE

The emergency brake systems on some naval aircraft are air systems that are completely separated from the hydraulic braking system. (See fig. 7-3.) A control valve is required to provide a means of releasing emergency air to the brakes for several applications. Figure 7-17 illustrates the emergency brake actuating valve utilized in the P-3A. The valve lever is operated through a cable arrangement from the flight station. It has four ports: pressure in, exhaust, and two brake ports. In the OFF position, pressure from the air reservoir is blocked, and both brake ports are open to exhaust. In the ON position, up to 1,500-psi air pressure may be transmitted to the brake ports. Releasing the lever shuts off the pressure, and brake port pressure is relieved through the exhaust ports. Because of this feature, the brakes may be operated several applications from a fully charged air bottle.

Operation of the valve lever moves the aft poppet forward against the aft end of the tube. The tube transmits this movement to the forward poppet assembly moving it away from its seat and allowing air from the emergency reservoir to flow to the brakes. When the actuating lever is released the aft and forward poppets return to their seats, and air within the brake system vents through the exhaust ports by flowing through the tube assembly.

MISCELLANEOUS COMPONENTS

A variety of miscellaneous components found in most all aircraft hydraulic systems is utilized in the aircraft brake systems. Several of these components are discussed in the following paragraphs.

Swivels

A variety of swivel joints is utilized throughout hydraulic systems to provide a movable connection between those lines attached to the aircraft structure and those lines attached to movable parts such as wing folds, landing gear, etc. Figure 7-18 illustrates the upper brake swivel joint utilized in the A-6A brake system. The swivel provides a rotating hydraulic connection between hydraulic lines from the overhead aircraft structure and the shock strut.

The swivel consists of an outer body that rotates about a fixed inner body when the landing gear rotates to the up position. Each part of the body contains two fluid passages: one for normal brake pressure and one for emergency pressure. O-rings and backup rings provide a seal between the bodies to prevent hydraulic fluid leakage.

Organizational maintenance of the valve consists of removal and replacement. Intermediate maintenance is limited to replacement of materials provided in the cure-date seal kit and the retainer (3). When assembling swivels of this sort, gently push the outer body over the inner body with a slight oscillating motion to prevent damage to the O-rings and backup rings. A light coating of hydraulic fluid is applied to all O-rings, backup rings, and mating surfaces prior to reassembling. Following reassembly, the swivel is bench-tested.

Proof testing is accomplished by applying 4,500 psi individually to each port with the opposing port plugged. The pressure should be maintained for 2 minutes and there should be no leakage. This check should be conducted a minimum of three times and during the last proof test the swivel should be rotated through a complete swiveling circle. The static leak test is conducted in the same manner as the proof test using 5 to 10 psi. Next apply 3,000 psi to both the normal and emergency ports with the opposing ports plugged. Gradually apply and check the torque required to rotate the swivel. Maximum torque required should not exceed 30 inch-pounds.

In the final step of testing, apply low pressure to each port with the opposing port unplugged and check that fluid flows freely through the swivel. If the swivel is ready for issue and is to be returned to supply for stock, flush it with preservative hydraulic fluid and plug all ports. If the part fails the testing, it should be tagged to show the part of the test failed, flushed with preservative hydraulic fluid and plugged, and then forwarded by supply to the next higher level of maintenance.

Thermal Relief Valves

Thermal relief valves similar to the typical one illustrated in the *AMH 3 & 2 Rate Training*

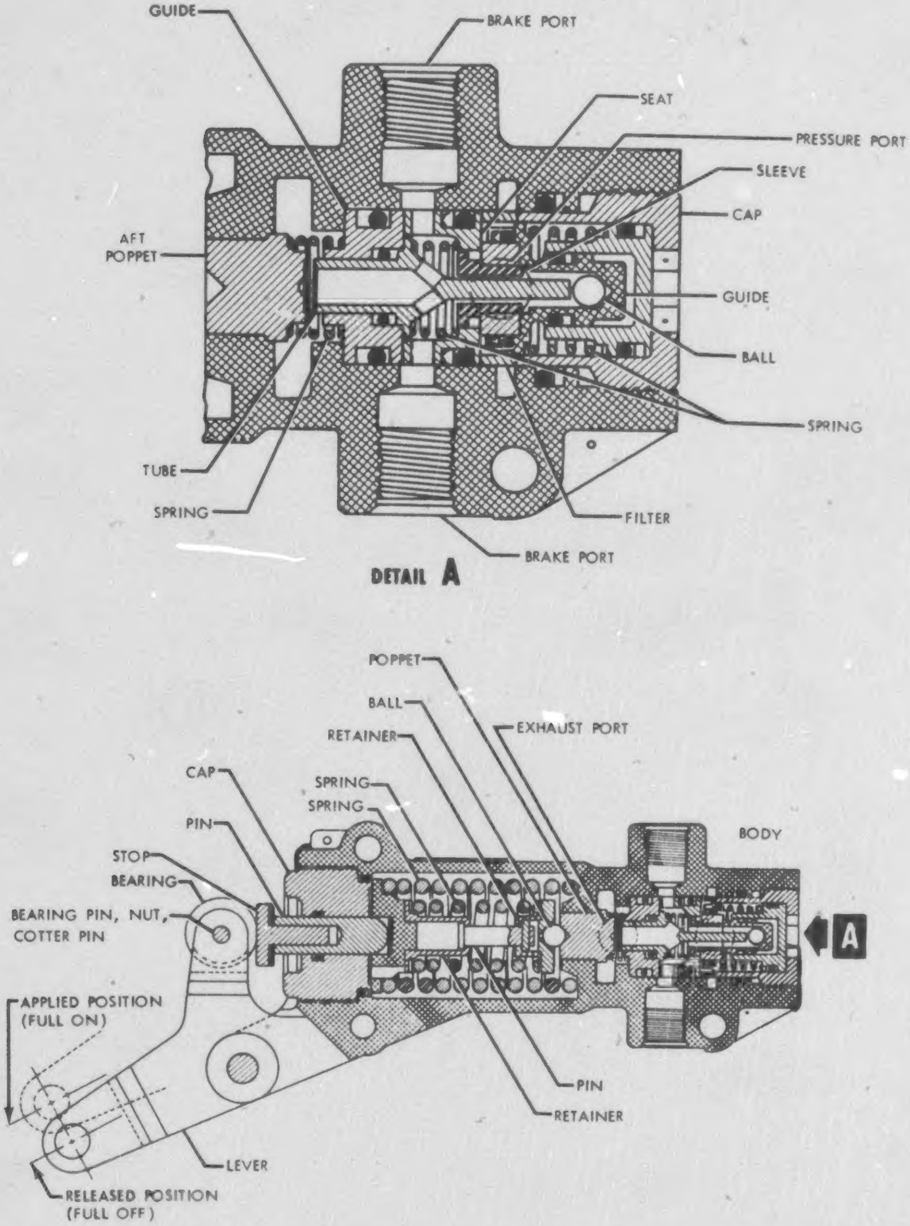

GUIDE
BRAKE PORT
SEAT
PRESSURE PORT
SLEEVE
CAP
AFT POPPET
GUIDE
BALL
SPRING
TUBE
SPRING
FILTER
BRAKE PORT
DETAIL A
POPPET
BALL
RETAINER
EXHAUST PORT
CAP
SPRING
SPRING
PIN
BODY
STOP
BEARING
BEARING PIN, NUT, COTTER PIN
A
APPLIED POSITION (FULL ON)
PIN
RETAINER
LEVER
RELEASED POSITION (FULL OFF)

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Figure 7-17.–Emergency brake actuating (air modulator) valve.

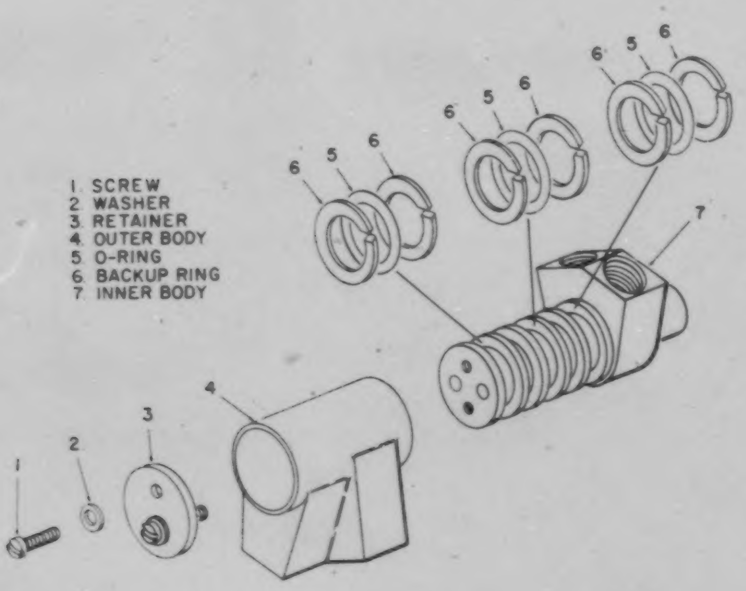

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Figure 7-18.—Upper brake swivel—A-6A.

Manaul are utilized in most brake systems to relieve thermal expansion created by the high temperature buildup when the brakes have been used excessively. Brake and wheel assembly temperatures become extremely high during hard braking of the aircraft, and temperatures peak after the aircraft has been stopped. When the temperature causes the fluid pressure to reach a predetermined setting the valve poppet in the thermal relief valve unseats and ports the excessive pressure to return lines. When the pressure decreases to the predetermined setting, the valve reseats.

Internal leakage through the valve may be checked by observing the return port with the valve pressurized. Proper operation of the valve must be checked, utilizing a test bench. Like most relief valves, the opening pressure may be increased by turning the adjusting screw clockwise and decreased by turning the adjusting screw counterclockwise. The adjustment of the adjusting screw or nut determines the amount of tension that is placed against the valve poppet, thus regulating the opening and closing pressure required.

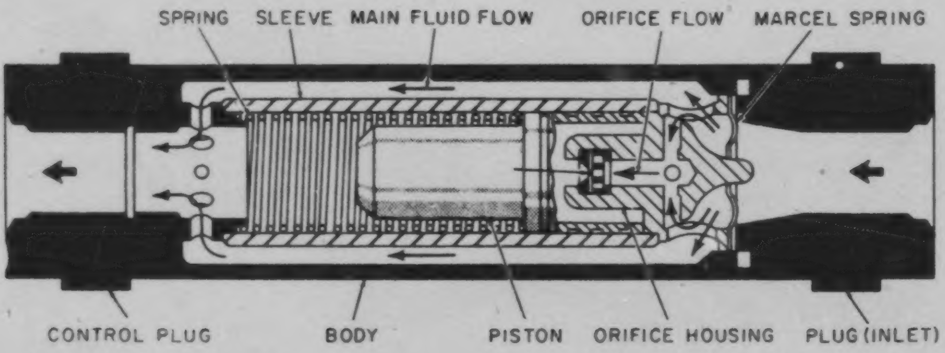
Accumulators

Accumulators are utilized in brake systems to provide an emergency source of pressure for operating the brakes when the normal system fails. The accumulator utilized in the A-6A brake system (fig. 7-2) provides 50 cubic inches of hydraulic fluid for emergency braking. The accumulator is precharged to 800 psi nitrogen pressure to push the fluid into the brake system. When the pressure has been depleted, it can be recharged by using the hydraulic handpump or, on some model A-6s, the electric motor-driven auxiliary hydraulic pump.

A cure-date seal kit is available for repairing the accumulator at the intermediate level of maintenance.

Fuses

Fuses are located in many brake systems to prevent the complete loss of fluid when a hydraulic leak occurs downstream of the fuse. The fuse illustrated in figure 7-19 is utilized in the A-6A braking system to prevent the complete loss of hydraulic fluid from the accumulator if a leak should occur in the brake



216.98

Figure 7-19.—Hydraulic fuse.

cycles gage (fig. 7-2) or the line going to it. Fluid loss is limited to 1.8 cubic inches.

The fuse piston slides inside the sleeve suspended between the control plug and the orifice housing. The light spring inside the sleeve holds the piston in the starting position when there is no fluid flow.

The hydraulic fuse operates on the ratio of the flows through the annular (main) passage and orifice passage. Metering flow through the orifice is created by the pressure drop of the main flow through the orifices at the outlet of the main passage. Metering flow moves the piston, against the force of its spring, toward the control plug seat. When there is no large leak downstream of the fuse, the piston will not seat, as the required quantity of fluid will not flow through the fuse. When the pressure in the fuse becomes static, the spring tends to return the piston to its starting point. This return requires a relatively long time as the orifice arrangement within the orifice housing is designed to act as a check valve. When the pressure upstream of the fuse is reduced below that which is trapped within the brake cycles gage and line, flow through the fuse is reversed. The piston now moves in the opposite direction, and since there is virtually no restriction to reverse flow through the metering circuit, the piston quickly returns to the start position.

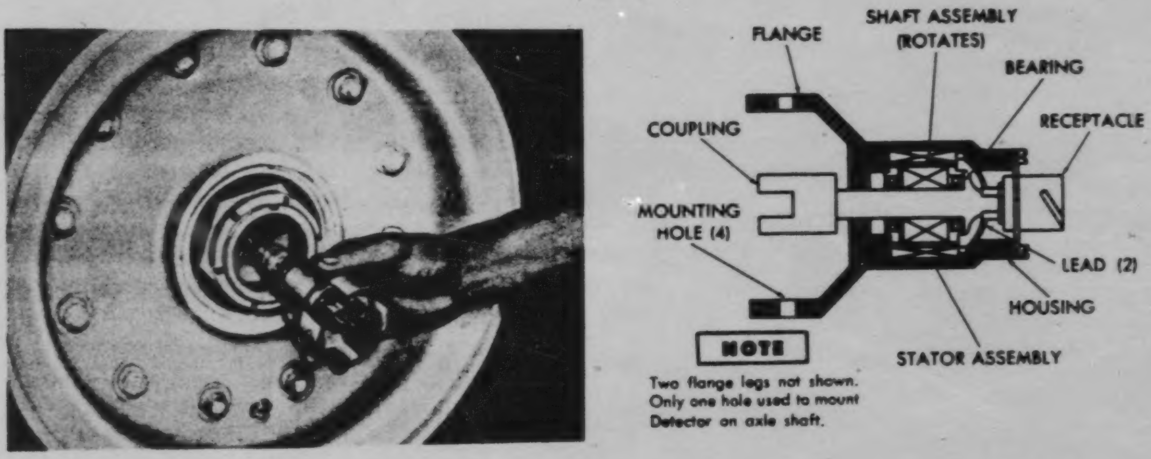
When there is a large leak downstream of the fuse, the piston is closed to the seat in the control plug after the required volume of fluid has passed. Continued flow through the fuse moves the piston completely into and against the seat, stopping all flow. As long as high pressure holds the fuse seated, no more fluid will be lost.

Check Valves

Basic spring-loaded ball-poppet check valves similar to the one described in the *AMH 3 & 2 Rate Training Manual* are utilized in most brake systems to allow free flow of fluid in one direction and prevent reverse flow caused by pressure differentials. Arrows are located in two places on most check valves to indicate the direction of free flow. A spring-loaded poppet in the valve, normally held open by fluid pressure in the free flow direction, seats under reverse flow pressure to prevent passage of fluid. The free flow opening pressure for most check valves is very low (3 to 5 psi). Maintenance of check valves is adequately covered in *AMH 3 & 2*, and no further coverage is provided.

SKID CONTROL SYSTEM

Many of the late model aircraft are provided with a skid control system which operates in conjunction with the brakes. Figure 7-2 illustrates the antiskid control valve installed in the A-6A braking system. The main components of the system are the antiskid control valves, the antiskid control box, and the antiskid detectors. The antiskid control system is an automatic, electrohydraulic-type control, functioning as an auxiliary to the regular braking system. The system is used during land-based operations to afford maximum braking without skidding.



Two flange legs not shown. Only one hole used to mount Detector on axle shaft.

216.99

Figure 7-20.—Antiskid detector (A-6A).

When the system is in operation, braking is accomplished through the antiskid control valve, which releases and applies brake pressure in response to signals from the antiskid control box. An antiskid detector, located in each wheel axle, generates an ac voltage whose amplitude is directly proportional to wheel rotational speed. This voltage is applied to the antiskid control box, which detects any difference in the rotation of either main gear wheel and applies the necessary electrical signal to the antiskid control valve to control the skid before it occurs. The skid detector illustrated in figure 7-20 is a small rugged unit. It consists of an electrical alternator sensing device with electrical leads running from the stationary windings to the skid control box. The alternator has a voltage-to-speed relationship of approximately 1 volt per 100 rpm. The power output is low since its function is only to supply a signal current to the control box for amplification. The detector is sealed from all adverse environmental conditions.

The antiskid control box detects the beginning of wheel skids and/or locked wheel condition of the main landing gear wheels. In conjunction with the detectors and the antiskid control valves, the control box provides skid control in two steps—modulated braking control and fast ON-OFF brake release.

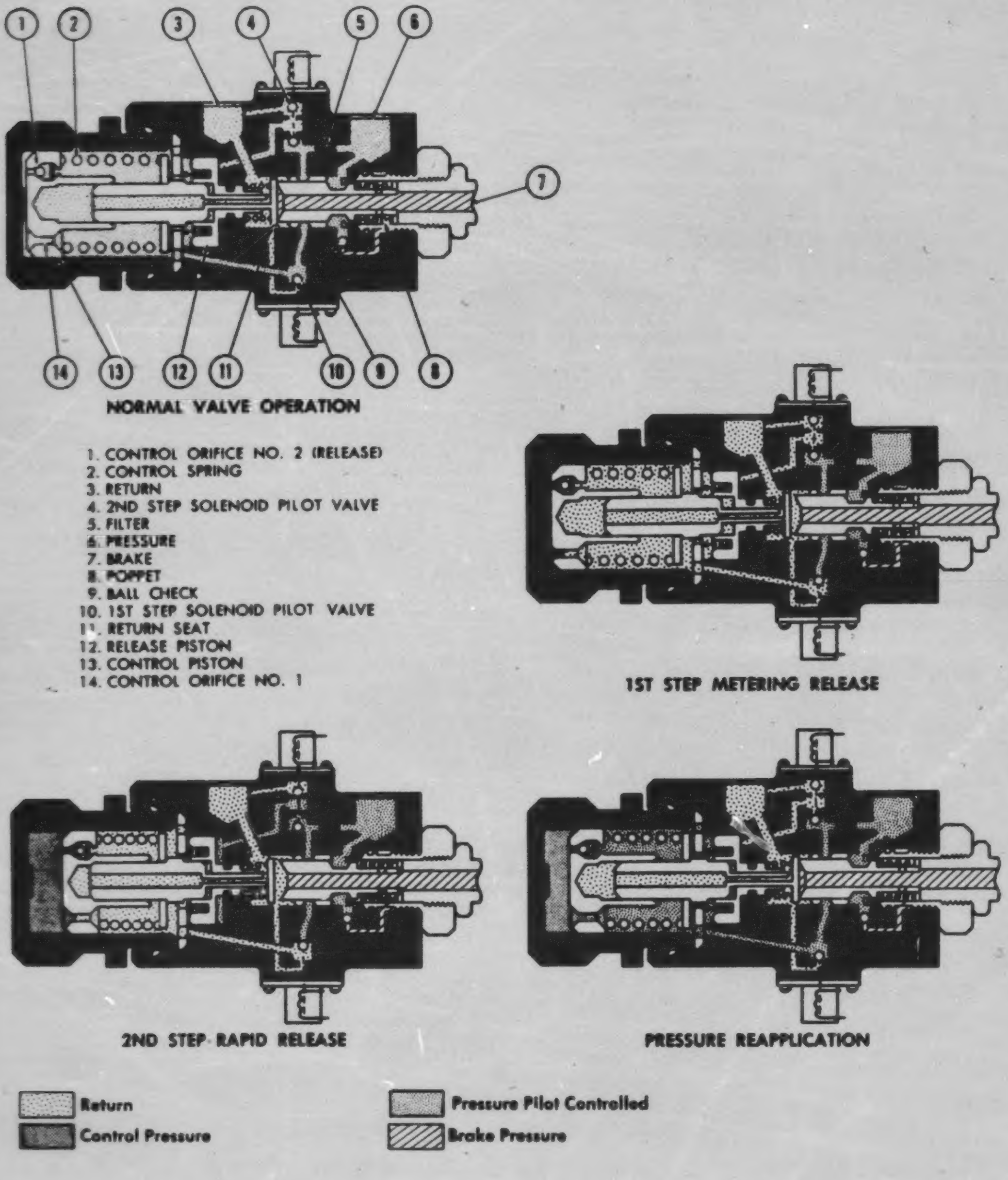
Locked wheel control is provided by a sensing circuit within the control box whenever a wheel rotates below a specified speed or stops. The antiskid control box operation is entirely automatic.

Operation

When the aircraft is making an approach for a landing with the antiskid system energized, braking is prevented until after touchdown by the action of the steering weight-on-wheels switch and the locked wheel sensing circuit of the antiskid control box.

As the aircraft touches down and the pilot actuates the brake pedals, instant brake action is prevented until the aircraft's weight compresses the weight-on-wheels switch which, in turn, deenergizes the locked wheels sensing circuit until it can be rearmed by the rotation of the antiskid detectors.

As a result of wheel rotation, the voltage output of the detector is supplied to the control box. The box compares the signals from both detectors and supplies an electrical output to the step No. 1 or step No. 2 solenoids of either or both antiskid control valves. Figure 7-21 illustrates the various functions of operation performed by the antiskid control valves. If the releasing of the brakes to control skid is in


1
2
3
4
5
6
7
8
9
10
11
12
13
14
NORMAL VALVE OPERATION
1. CONTROL ORIFICE NO. 2 (RELEASE)
2. CONTROL SPRING
3. RETURN
4. 2ND STEP SOLENOID PILOT VALVE
5. FILTER
6. PRESSURE
7. BRAKE
8. POPPET
9. BALL CHECK
10. 1ST STEP SOLENOID PILOT VALVE
11. RETURN SEAT
12. RELEASE PISTON
13. CONTROL PISTON
14. CONTROL ORIFICE NO. 1
1ST STEP METERING RELEASE
2ND STEP RAPID RELEASE
PRESSURE REAPPLICATION
Return
Control Pressure
Pressure Pilot Controlled
Brake Pressure

216.100

Figure 7-21.—Antiskid control valve schematic (A-6A).

excess of 4 seconds, a fail-safe timing circuit within the control box returns the braking system to full manual braking.

The skid control valve is a three-way, solenoid-operated valve. See figure 7-2 for location of the valve in the landing gear schematic. The valve has two steps of operation, each controlled by the solenoid-operated pilot. The first step provides modulated brake pressure by controlling its increase or decrease to a relatively low rate of pressure change. The second step provides rapid complete brake release followed by rapid return of pressure to a value slightly less than the pressure existing at the time of release.

Upon the first application of brake pressure, the valve is fully open (from pressure source to brake port) to allow fast flow of hydraulic fluid into the brakes until low pressure braking action starts. At this low pressure, the solenoid valve meters brake pressure into the brakes at a predetermined rate that requires approximately 2 seconds for full brake pressure buildup. This relatively slow buildup of brake pressure assures that skid control can take place before there is severe overbraking pressure directed to the brake assemblies.

The normal operation view in figure 7-21 shows the deenergized valve position at the initial application of brakes. The poppet is open, permitting pressure to act on the brake due to the preload of the control spring. When the brake pressure reaches 150 to 200 psi, the force on the return seat area equals the spring preload and the metering action starts.

In the 1st step metering release view, the lower pilot valve is actuated to allow flow of fluid out of the control cylinder. The return seat opens to return and allows the brake pressure to be reduced in proportion to the decreasing spring force. Spring force is regulated by the position of the control piston. The piston's position is controlled by the fluid flow through both control orifices. By the use of two orifices, one with a check valve, different rates of release and reapplication are possible.

In the 2nd step rapid release view, both pilot valves are energized. Flow through the upper pilot valve causes the release piston to move rapidly to the left, opening the return seat, and releasing brake pressure. Simultaneously, the control spring force is being reduced by flow out through the lower pilot valve. The longer the release lasts, the lower the pressure will be upon reapplication.

In the pressure reapplication view, hydraulic fluid flows through the lower pilot valve to the control cylinder. The differential area between the rod and head end of the control piston causes flow through control orifice No. 1 only. The control piston moves to the right at a rate dictated by the size of the orifice, increasing the spring load. This action opens the pressure poppet so that the brake pressure on the return seat area always balances the increasing spring force.

When wheel rotation is applied to the antiskid detector in the wheel axles, the shaft assembly (fig. 7-20) rotates within the stator assembly and an electrical signal, whose amplitude is proportional to wheel speed, is sent to the speed sensing circuit within the antiskid control box. When wheel speed decreases sharply at the beginning of a skid, the speed sensing circuit applies an output signal to the rate sensing network. A small decrease in wheel speed causes the rate sensing network to energize the step No. 1 circuit and subsequently the step No. 1 solenoid in the antiskid control valve. A further decrease in wheel speed energizes the step No. 2 solenoid. When the aircraft is in flight, the lock wheel sensing circuit within the control box is energized by the steering weight-on-wheels switch and no brake pressure is applied at touchdown, thus preventing a locked wheel condition.

Maintenance

An antiskid test set is available for personnel in the AE rating to utilize in operational checks of the antiskid system. The operational test normally requires a joint effort on the part of both AE and AM personnel.

Organizational maintenance on the antiskid control valve is limited to removal and replacement. Intermediate level repair of the valve consists of cure-date seal and miscellaneous parts replacement in accordance with the procedures provided in the Intermediate Maintenance section of the Maintenance Instructions Manual. Following repair, the valve must be tested to verify proper operation both hydraulically and electrically.

Trouble Analysis

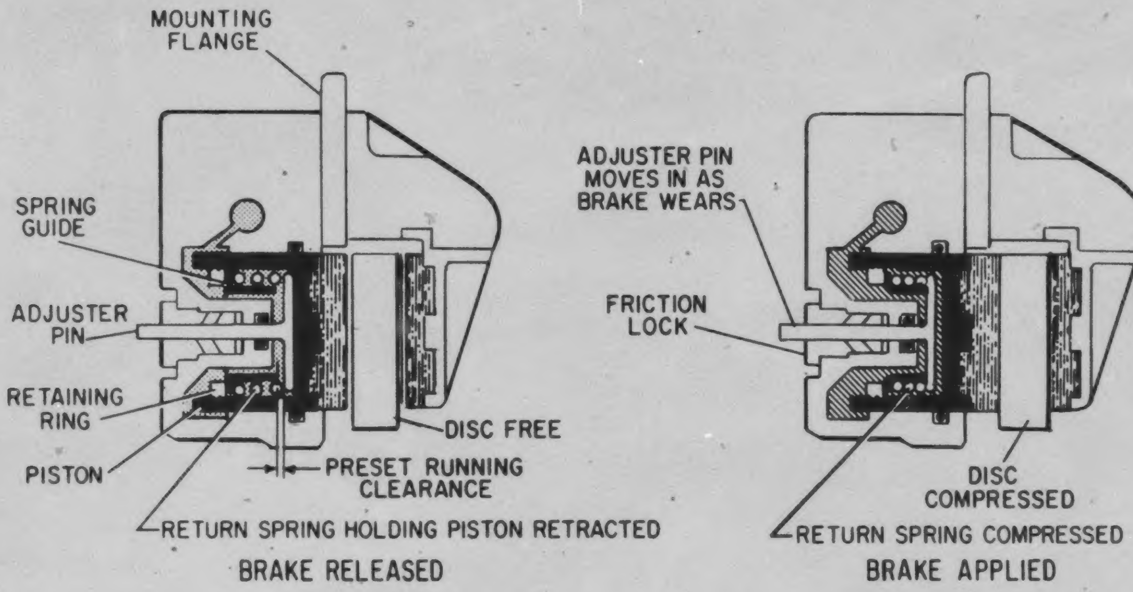
Trouble analysis/troubleshooting of the antiskid system is generally accomplished by personnel within the AE rating. The steps provided for using the antiskid test set will pinpoint the causes for most malfunctions. These steps that do not meet the results specified are investigated, parts are replaced as necessary, and the complete operational checkout is repeated to verify that the malfunction has been corrected.

BRAKE ASSEMBLY MAINTENANCE

The description and operation of the single and dual disc, multiple disc, segmented rotor, and expander tube type brake assemblies are provided in the *AMH 3 & 2 Rate Training Manual,* and knowledge of that material is presumed. Coverage of brake assemblies in this section includes a description and operation of the trimetallic disc brake assembly found on several model aircraft and additional maintenance information pertaining to the various brake assemblies used on present naval aircraft.

SINGLE AND DUAL DISC BRAKE MAINTENANCE

Automatically adjusted single and dual disc brakes are designed to provide a satisfactory running clearance between the brake disc and the brake linings. The self-adjusting feature of the brake maintains the desired lining/puck-to-disc clearance, regardless of lining/puck wear. (See fig. 7-22.) When the brakes are applied, hydraulic pressure moves each piston and its pucks/linings against the disc or discs as applicable. As the linings wear, the piston pushes against the adjusting pin, (through the spring guide) and moves the pin against the friction of the adjusting pin grip. When brake pressure is released, the force of the return spring moves the piston away from the brake


MOUNTING FLANGE
SPRING GUIDE
ADJUSTER PIN
RETAINING RING
PISTON
DISC FREE
PRESET RUNNING CLEARANCE
RETURN SPRING HOLDING PISTON RETRACTED
ADJUSTER PIN MOVES IN AS BRAKE WEARS
FRICTION LOCK
DISC COMPRESSED
RETURN SPRING COMPRESSED

BRAKE RELEASED

BRAKE APPLIED

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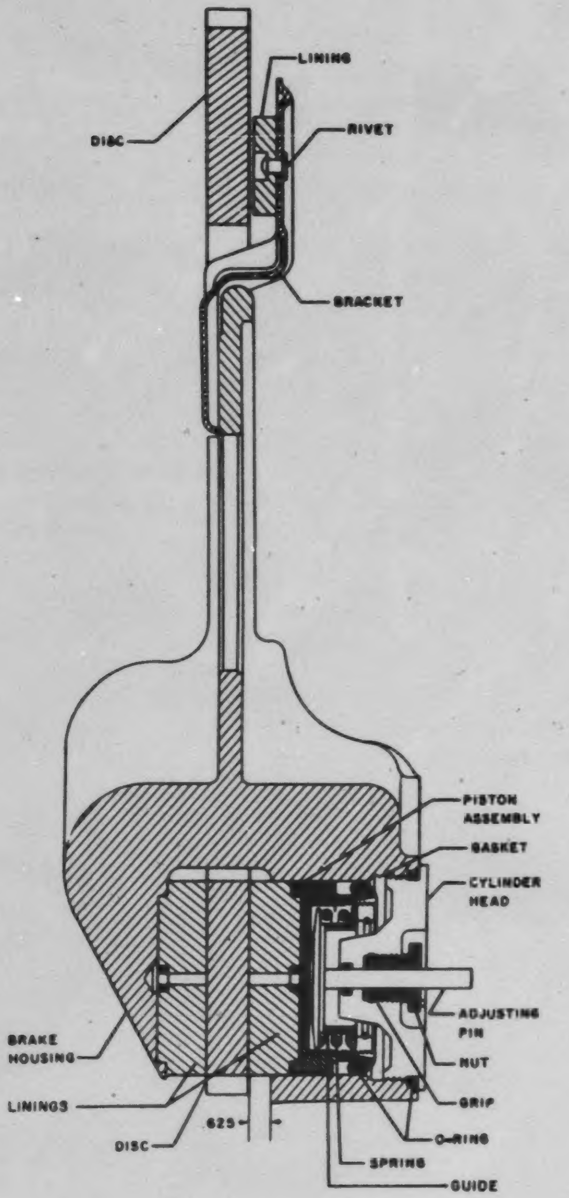
Figure 7-22.–Brake self-adjustment feature–single disc brake.



216.102

Figure 7-23.—Cross sectional view of single disc brake assembly with captured torquing type automatic adjuster.

disc but does not move the adjusting pin, which is held by the friction of the pin grip. The piston moves away from the disc until it stops against the head of the adjusting pin. Thus, regardless of the amount of wear, the same travel of the piston will be required to apply the brake, and the running clearance will be maintained.

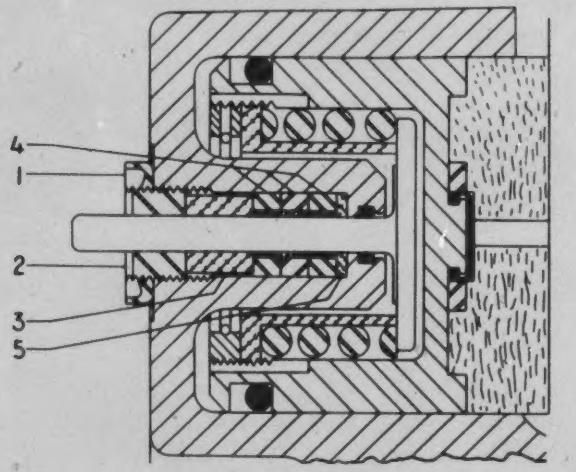
The automatic adjusting feature may be referred to as captured torquing type or captured nontorquing type. Figure 7-23 illustrates a typical captured torquing type automatic adjuster. It is mandatory that clearance be established between linings and the discs prior to torquing the automatic adjusting nut to the amount specified for the brake involved, or the brake will drag until an amount equal to the built-in-clearance is worn from the face of the linings. With the adjusting nuts properly torqued, the friction between the grip and the adjusting pin is great enough to overcome the compression of the return spring, and the adjusting pin will be pulled through the grip only to compensate for lining wear.

When torquing the automatic adjusting nuts to the specified value, torque the nut then back it off and retorque several times to ensure proper mating of all parts and correct torque on the final torquing.

Figure 7-24 illustrates the captured nontorquing type automatic adjuster utilized on some single and dual disc brake assemblies.

Brakes containing nontorquing adjusters can be identified by the locknut and threaded bushing over each adjusting pin. The only difference between the torquing and nontorquing type automatic adjustment is the method utilized to restrict the movement of the adjusting pin. The torquing type adjustment utilizes a tapered grip, and the nontorquing utilizes one or more 1/4-inch wide grips composed of brass liners.

Spare grips are shipped with pilot pins installed to open the grip to the approximate diameter of the adjusting pin, thus preventing damage to the grip during installation. The pilot pin is expelled as the grip is forced over the adjusting pin. If grips are to be reused when a brake is disassembled, they should have the pilot pins reinstalled prior to assembly in the brake.



1. Locknut.
2. Threaded bushing.
3. Spacer.
4. Grips, split collar.
5. Washer.

216.103

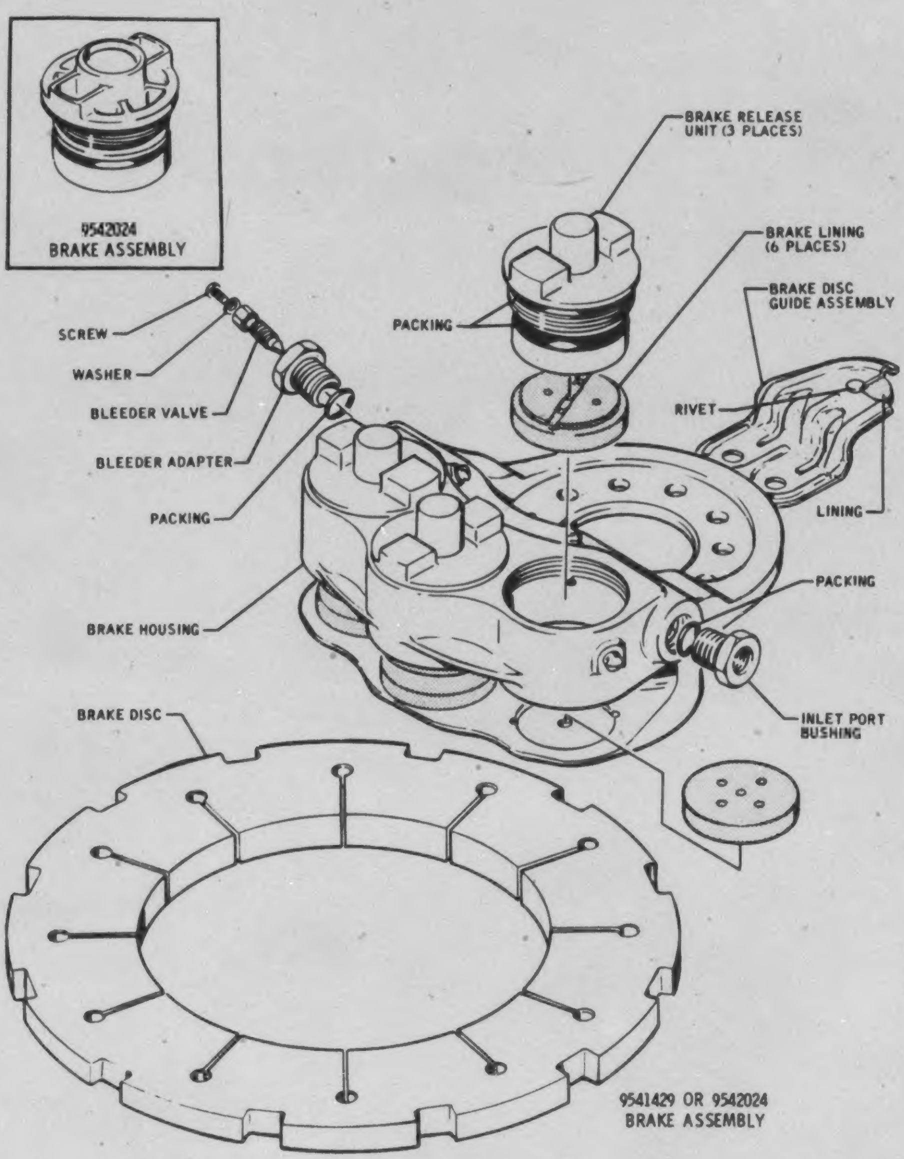
Figure 7-24.—Captured nontorquing type automatic adjuster.

Brake repairs on the single disc brake, illustrated in figure 7-25, consist of replacing linings, worn or damaged sealing devices, brake release units, or brake discs.

Lining replacement and cure-date kit installation consists of the following steps:

1. Remove the lockwire and unscrew the cylinder heads (brake release units); remove the release units from the housing.
2. Remove the disc from the brake housing.
3. Remove the inlet plug and busing, the bleeder adapter, and O-ring packings.
4. Remove the brake linings from the pistons, the brake housing, and the disc guide.
5. Clean the brake assembly components using low-pressure compressed air; wash all metal parts in cleaning solvent; and dry with compressed air.
6. Check the release units for damage, nicks, and gouges. If damaged, replace the complete release unit.
7. Check the brake housing for cracks and cylinder walls for nicks or other visible damage. Damage will necessitate turning in the complete brake assembly to supply for disposition.
8. Install new linings in the housing cavities and rivet on the disc guide lining. Friction fit will hold the linings in the housing cavities—do not use cement.
9. Install new linings in the piston cavities using brake lining adhesive specified for such use (e.g., Pliogrip No. 3).
10. Install the brake disc into the brake housing.
11. Dip brake release unit packings from the cure-date kit into hydraulic fluid and install on the brake release units.
12. Coat the piston of the release unit with a light coating of hydraulic fluid and install in the housing. Tighten the cylinder heads against the housing as specified in the *Maintenance Instructions Manual* or the 03 Manual.
13. Reinstall the inlet plug, bushing, and bleeder adapter into the housing, using new packings that have been dipped in hydraulic fluid.
14. Lockwire the cylinder heads, bleed the brake, and test the brake for leakage and proper operation. Test pressure for this brake assembly is 1,100 psi. Hold the pressure for 2 minutes and check the assembly for leaks. Release and reapply the pressure 10 times checking for proper brake operation and release of the discs. Allow the brake to stand 2 minutes with pressure relieved to check for static fluid leakage.

On dual disc brakes as well as some single disc brakes, the linings may be replaced without disturbing the brake hydraulic system. (See fig. 7-26.) In this example the shock strut is raised with a wheel jack until the wheel is clear of the ground. The wheel is removed, and the four internal wrenching bolts that attach the brake housing to the back plate are removed. The two setscrews located at each side of the brake housing are unscrewed enough to allow removal of the seven axle flange attaching bolts. Make certain the brake assembly is supported before removing the bolts, or damage to the brake hose could result. Remove the brake linings from the pistons, center carrier, backplate, and disc guide. Riveted linings must be drilled, and snap-on or friction-fit linings can be easily pried off with a common screwdriver. Dirt and other foreign particles are removed from the brake assembly

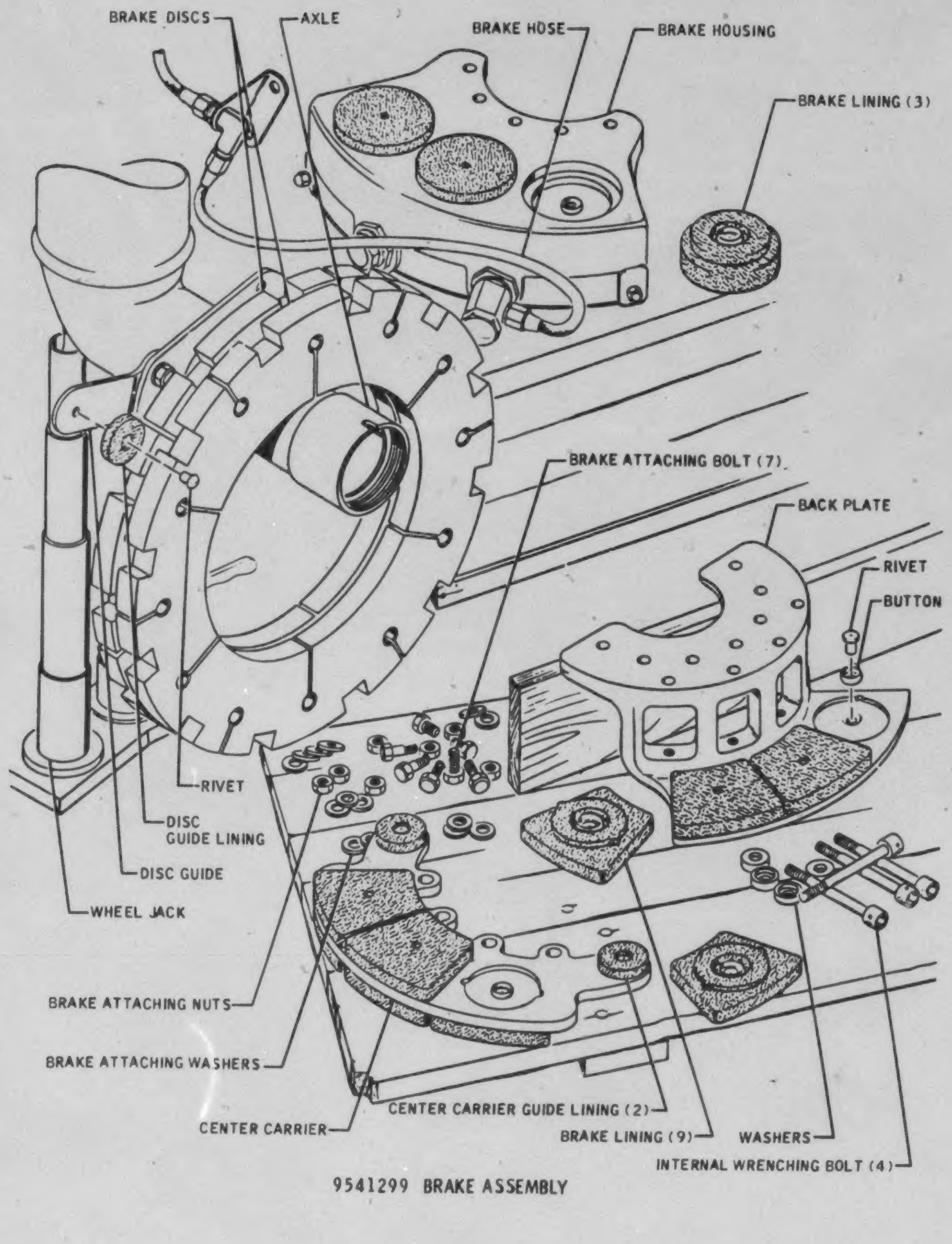

9542024
BRAKE ASSEMBLY
BRAKE RELEASE UNIT (3 PLACES)
BRAKE LINING (6 PLACES)
BRAKE DISC GUIDE ASSEMBLY
PACKING
SCREW
WASHER
BLEEDER VALVE
BLEEDER ADAPTER
PACKING
RIVET
LINING
PACKING
BRAKE HOUSING
BRAKE DISC
INLET PORT BUSHING
9541429 OR 9542024
BRAKE ASSEMBLY

216.104

Figure 7-25.—Single disc brake—repair and parts replacement sheet.

components by using low-pressure compressed air. Safety eye protection should be worn during this operation.

The external surfaces of the brake components can be cleaned with a cloth dampened with clean solvent (P-D-680). Any brake lining attaching buttons that are damaged should be replaced. The housing, backplate, center carrier, and all bolts should be inspected for damage, cracks, or leakage as applicable. If


BRAKE DISCS
AXLE
BRAKE HOSE
BRAKE HOUSING
BRAKE LINING (3)
BRAKE ATTACHING BOLT (7)
BACK PLATE
RIVET
BUTTON
RIVET
DISC GUIDE LINING
DISC GUIDE
WHEEL JACK
BRAKE ATTACHING NUTS
BRAKE ATTACHING WASHERS
CENTER CARRIER
CENTER CARRIER GUIDE LINING (2)
BRAKE LINING (9)
WASHERS
INTERNAL WRENCHING BOLT (4)
9541299 BRAKE ASSEMBLY

216.105

Figure 7-26.–Dual disc brake–repair and parts replacement.

the brake has hydraulic leakage or if the housing, backplate, or center carrier is damaged or cracked, the complete brake assembly should be replaced and turned in to supply for repair at the next higher level of maintenance.

Inspect the brake discs for excessive wear or warping. The disc should be inspected for minimum thickness, maximum width of the keyways, and warping. The discs may be checked for warping by using a straightedge across the face of the disc. Instructions concerning straightening a warped disc may be found in the applicable *Overhaul Instructions Manual* (03 publication). A brake disc that is worn excessively should be replaced.

When a brake disc keyway is worn excessively or elongated, the brake disc drive keys within the wheel assembly should be inspected for damage and security. The drive keys or the wheel should be replaced if the damage exceeds the limitations specified in the applicable *Maintenance Instructions Manual.*

The new linings are installed in the brake pistons, the center carrier, and the backplate; and the disc guide lining is riveted to the disc guide. The pistons are pushed back into the piston housing until a maximum of 1/8 inch of lining is protruding beyond the housing. The brake is reassembled on the axle flange, and all attaching bolts as well as the four internal wrenching bolts are torqued to the specifications provided in the *Maintenance Instructions Manaul.* The fore and aft axle attaching nuts on the brake housing must have their flat surface toward the setscrew on the final torque. The setscrews are tightened against the flat surfaces to safety the nuts. The four internal wrenching bolts are secured with lockwire. The wheel is installed and the shock strut lowered. An operational check should be performed to verify proper operation. Specified steps throughout the lining and disc replacement procedure and the final security of all attachments require quality assurance verification as indicated in the *Maintenance Instructions Manual.*

Seal Replacement and Piston Return Adjustment

Figure 7-27 illustrates the various steps involved in replacing the piston seals and adjusting the return mechanism. The internal wrenching bolts holding the cylinder housing to the carrier and back plate are removed (view A). The cylinder housing is placed under a press as illustrated in view B. Using the press and the drive pin, force the adjusting pins through their grips and remove the pistons from the housing. Make sure that the drive pin is centered on the adjusting pin to prevent damaging the adjusting pin packings and grips.

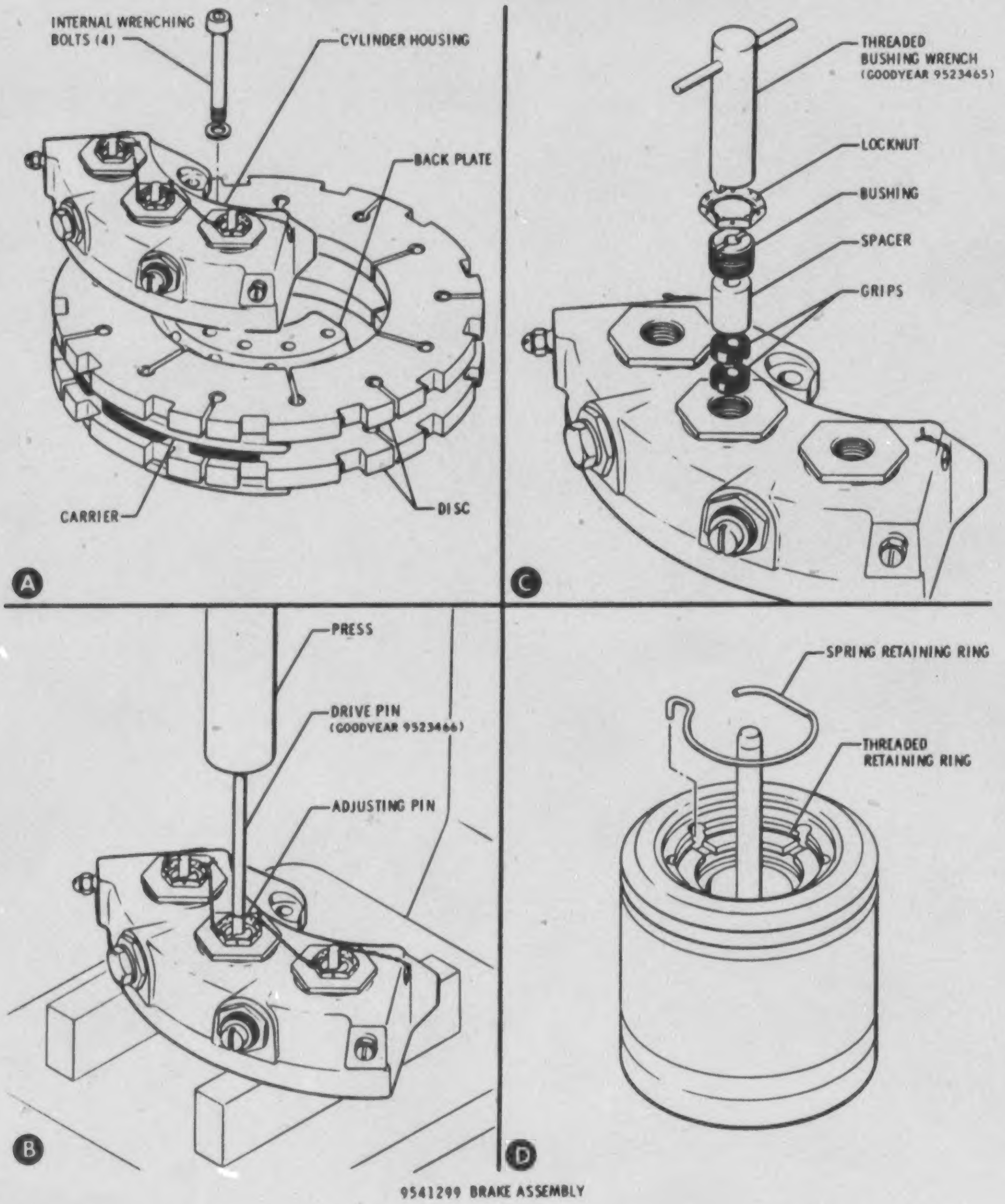
Next, cut the lockwire on the locknuts and, using the threaded bushing nut illustrated in view C, remove the locknuts, bushings, spacers, and grips from the housing. Remove the spring retaining ring from within the piston as shown in view D.

With the linings still attached to the pistons, support the pistons in a press and, using a 3-inch length of 7/8-inch steel tubing, force the guides to bottom on the adjusting pins as shown in view E. Holding the guides bottomed, turn the threaded retaining rings clockwise until the rings are snug against the bottom guides. Back off the threaded retaining rings 3/4-turn counterclockwise from the bottomed positions and, if necessary, continue turning counterclockwise to the next locking position as shown in view F. Secure the threaded retainer with the wire retaining ring.

Replace the piston packings with new packings that have been dipped in hydraulic fluid and ensure that the packings and adjusting pin stems are lubricated with hydraulic fluid.

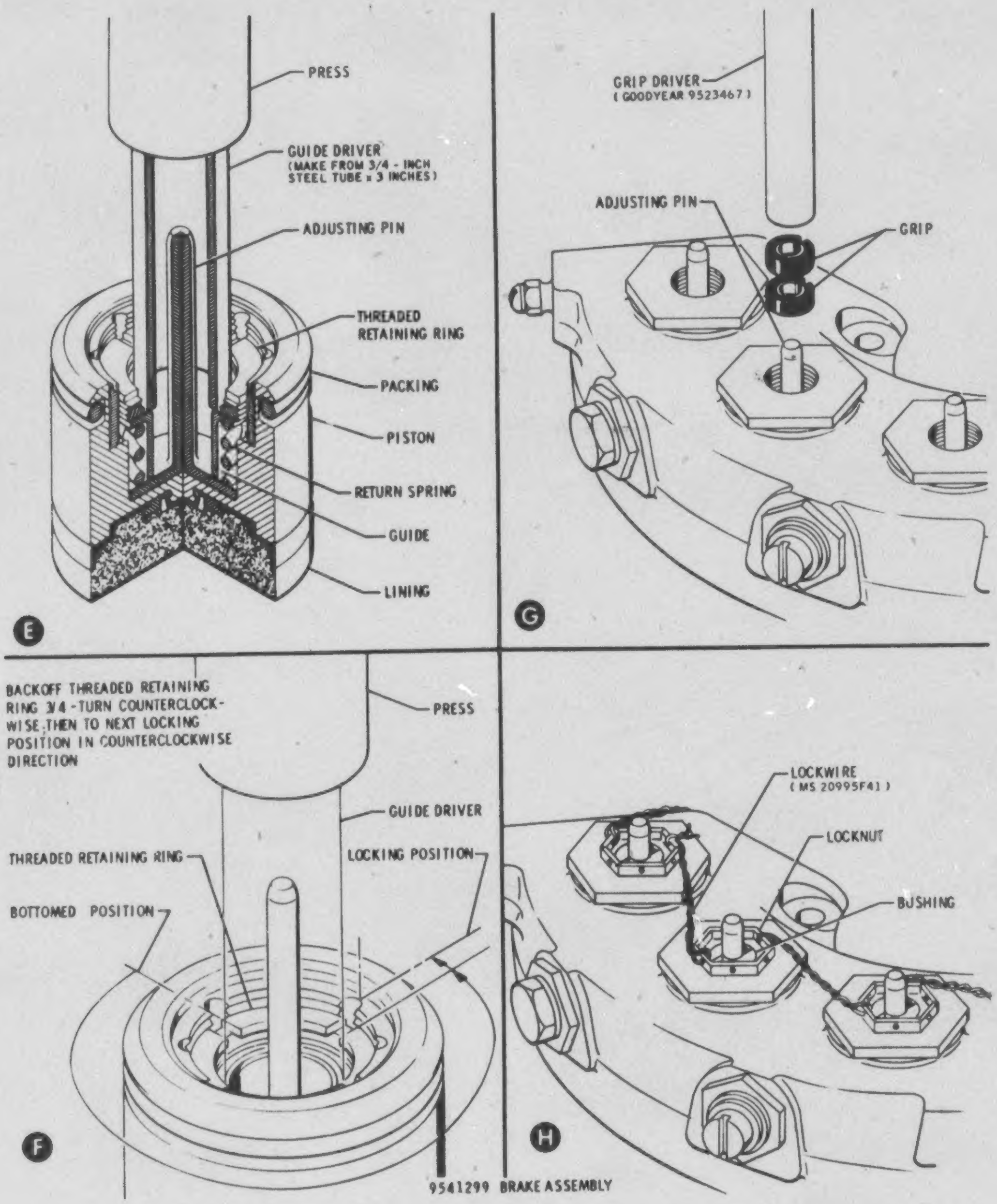
The piston assemblies are then installed in the cylinder housing and forced to the complete brake-off positions—bottomed in the housing cavities. The pistons are supported against their linings to the brake-off position and using the press and the grip driver as illustrated in view G, force the grips, one at a time, over the adjusting pins until bottomed. The pistons must remain in the complete brake-off position when installing the grips. Place the spacers over the adjusting pins and install the bushings fingertight. Hold the bushings in the fingertight positions and install and tighten the locknuts. Safety wire the locknuts as shown in view H.

NOTE: On some brake assemblies the adjusting pin bushing (adjusting pin nut) is torqued to a specified value.


INTERNAL WRENCHING BOLTS (4)
CYLINDER HOUSING
BACK PLATE
CARRIER
DISC
A
THREADED BUSHING WRENCH (GOODYEAR 9523465)
LOCKNUT
BUSHING
SPACER
GRIPS
C
PRESS
DRIVE PIN (GOODYEAR 9523466)
ADJUSTING PIN
B
SPRING RETAINING RING
THREADED RETAINING RING
D
9541299 BRAKE ASSEMBLY

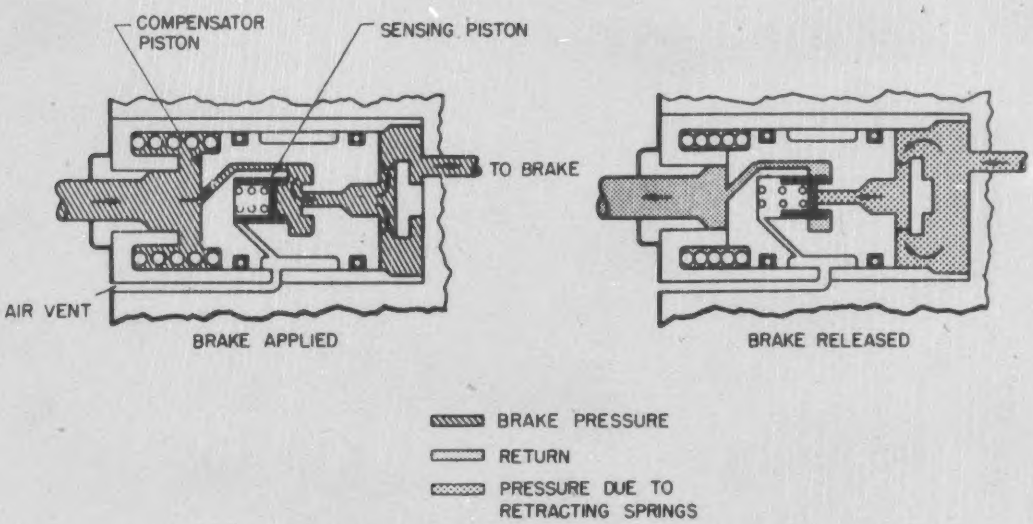
216.106

Figure 7-27.—Seal replacement and piston return adjustment.


PRESS
GUIDE DRIVER (MAKE FROM 3/4 - INCH STEEL TUBE x 3 INCHES)
ADJUSTING PIN
THREADED RETAINING RING
PACKING
PISTON
RETURN SPRING
GUIDE
LINING
E
GRIP DRIVER (GOODYEAR 9523467)
ADJUSTING PIN
GRIP
G
BACKOFF THREADED RETAINING RING 3/4 -TURN COUNTERCLOCKWISE THEN TO NEXT LOCKING POSITION IN COUNTERCLOCKWISE DIRECTION
PRESS
GUIDE DRIVER
THREADED RETAINING RING
LOCKING POSITION
BOTTOMED POSITION
F
LOCKWIRE (MS 20995F41)
LOCKNUT
BUSHING
H
9541299 BRAKE ASSEMBLY

216.106.1

Figure 7-27.—Seal replacement and piston return adjustment—Continued.



216.107

Figure 7-28.—Multiple disc brake automatic adjuster—schematic.

Following reassembly, the brake assembly must be tested. Connect the brake assembly to a hydraulic supply source. Bleed the brake assembly and apply 600 psi.

CAUTION: Prior to applying pressure, make sure that the brake is assembled properly with all bolts torqued and brake discs in position.

Hold the test pressure for 2 minutes while checking the brake assembly for leaks. Release and apply the pressure 10 times to be sure that the brake functions properly. The brake discs should be free when hydraulic pressure is released. Allow the brake to stand for 2 minutes with pressure released and check for static fluid leakage.

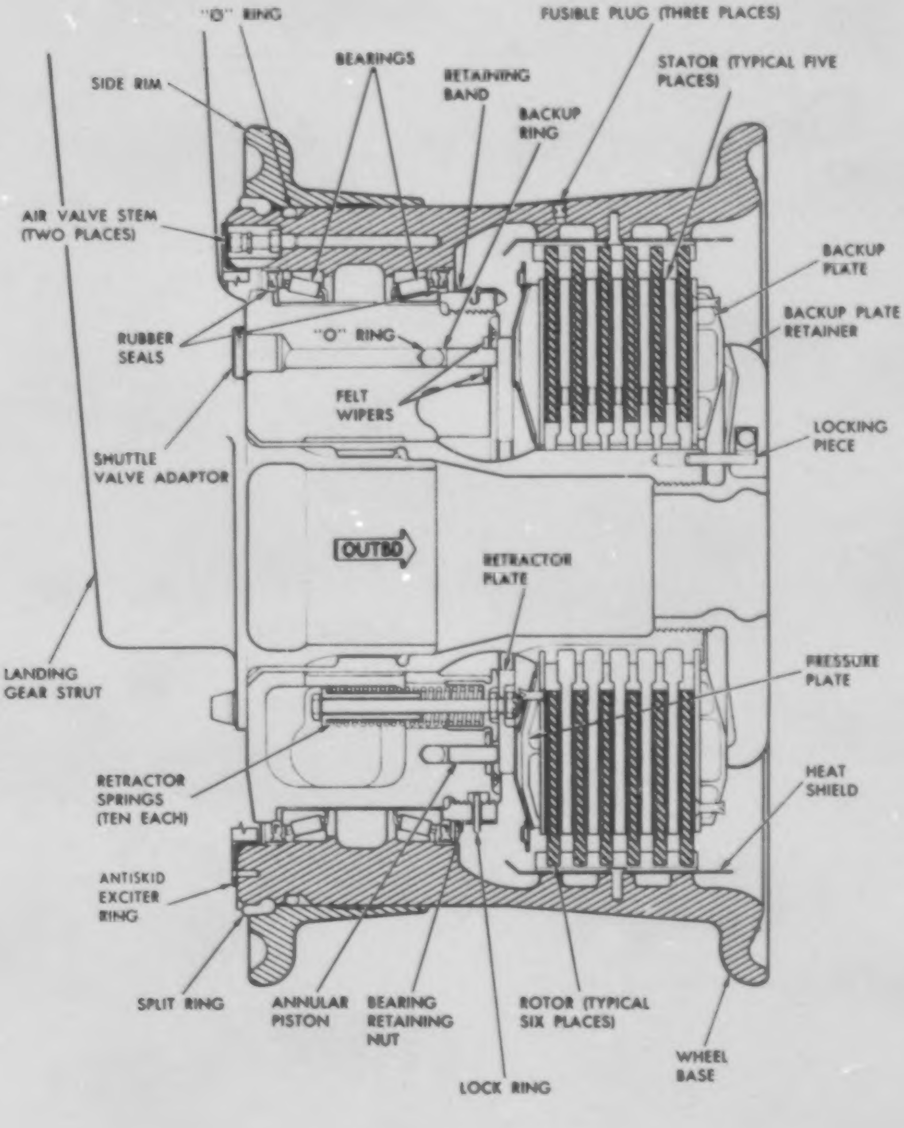
If the brake assembly is not to be installed immediately, install any attaching hardware that is part of the assembly, fill with preservative hydraulic fluid, and cap or plug any openings to prevent contamination.

MULTIPLE DISC BRAKE MAINTENANCE

Figure 7-28 illustrates the automatic adjuster utilized in one type of multiple disc brake. This type of adjuster is referred to as a "free" type adjustment. Proper adjustment of the brake is dependent upon hydraulic fluid remaining in the brake assembly cylinder to compensate for lining wear. When pressure is not applied to the brake, the disc will rotate with only a minimum of friction against the brake linings.

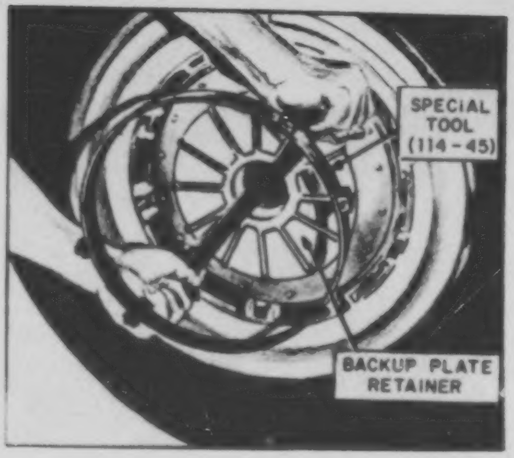
The automatic adjuster is located in the brake hydraulic line and is housed in the brake assembly. When the brakes are applied, fluid passes through a drilled passageway in the compensator piston and its forces are exerted on the sensing valve piston, causing it to open. At the same time, the pressure acts on the large area of the compensator piston, moving it and the trapped fluid ahead of it to obtain immediate braking action. When the desired amount of braking action is attained, the compensator piston is bottomed in the adjuster housing by spring tension, and the sensing piston is held open by hydraulic pressure. Fluid pressure is then balanced on both ends of the compensator piston. As the linings wear, the annular brake piston moves to maintain positive braking action. This piston movement increases the volumetric capacity of the piston and seal housing.

Upon release of the brake pedal, the hydraulic forces on the ends of the compensator piston become unbalanced as the pressure at the inlet side is relieved to system return. Fluid flow out of the brake is caused by action of the brake return springs on the annular piston and seal. This outflow from the brake moves the compensator piston to the released position. Simultaneously with the reduction of internal pressures, the sensing valve piston closes, trapping a predetermined amount of fluid pressure in the brake assembly. This trapped fluid prevents the return springs from returning the annular piston to the fully retracted


"O" RING
FUSIBLE PLUG (THREE PLACES)
BEARINGS
SIDE RIM
RETAINING BAND
STATOR (TYPICAL FIVE PLACES)
BACKUP RING
AIR VALVE STEM (TWO PLACES)
BACKUP PLATE
BACKUP PLATE RETAINER
RUBBER SEALS
"O" RING
FELT WIPERS
LOCKING PIECE
SHUTTLE VALVE ADAPTOR
OUTBD
RETRACTOR PLATE
LANDING GEAR STRUT
PRESSURE PLATE
RETRACTOR SPRINGS (TEN EACH)
HEAT SHIELD
ANTISKID EXCITER RING
SPLIT RING
ANNULAR PISTON
BEARING RETAINING NUT
ROTOR (TYPICAL SIX PLACES)
WHEEL BASE
LOCK RING

216.108

Figure 7-29.—Multiple disc wheel brake assembly.



216.109
Figure 7-30.—Backup plate retainer tool.

position, thus maintaining a suitable running clearance between the brake discs.

Maintenance

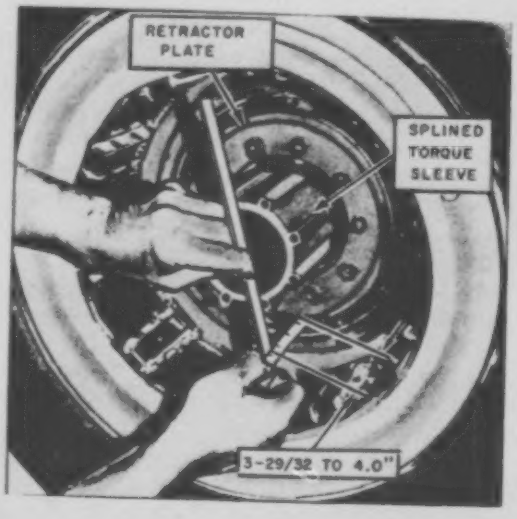
The *Rate Training Manual for AMH 3 & 2* provides some maintenance information on multiple disc brakes, and knowledge of that coverage is presumed. Figure 7-29 illustrates the multiple disc brake assembly utilized on the RA-5C. The brake assembly consists of the bearing carrier, bearings and retaining nut, the annular actuating piston, the heat stack, and retracting springs. The heat stack is composed of a pressure plate, rotors, stators, and a backup plate.

BACKUP PLATE RETAINER ADJUSTMENT.—Wheel running clearance is determined by proper adjustment of the backup plate retainer. The backup plate retainer is adjusted in the following manner:

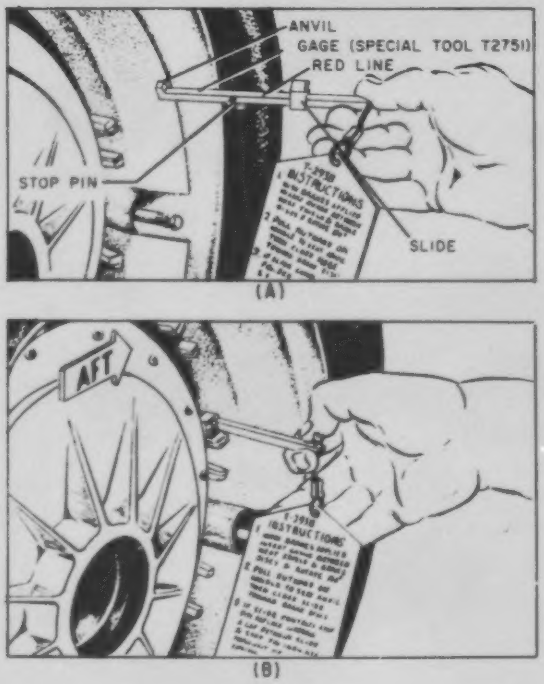
1. Ensure that the wheel brakes are not applied and then remove the retainer plate locking piece.
2. Tighten the backup plate retainer until the retainer is snug against the wheel pressure plate using the special tool as illustrated in figure 7-30. Apply only the maximum torque that can be exerted by one man on the special tool.
3. Note the position of the retainer plate, then back off the plate (counterclockwise) one complete turn to obtain the required wheel brake running clearance.
4. Tighten the retainer plate clockwise to the nearest locking piece hole and loosely install the locking piece. It is important that the locking piece bolt be loosely installed. Turn the nut fingertight only and then back off to the next cotter pin position in the slotted nut.

Proper installation of the backup plate is checked by pulling outboard against the retainer and attempting to rotate it. It should not be possible to rotate the backup plate more than a fraction of an inch, which indicates positive engagement with the splined torque sleeve. (See fig. 7-31.)

CHECKING HEAT STACKS.—Refer to figure 7-32. With the brakes fully applied, insert the gage between the heat shield and the brake discs as shown in view A. Rotate the gage 90 degrees and pull outboard on the gage to seat the anvil against the innermost brake disc. Close the slide against the outboard disc. If the red line on the gaging tool appears behind the slide,



216.110
Figure 7-31.—Measuring retractor plate retraction depth.



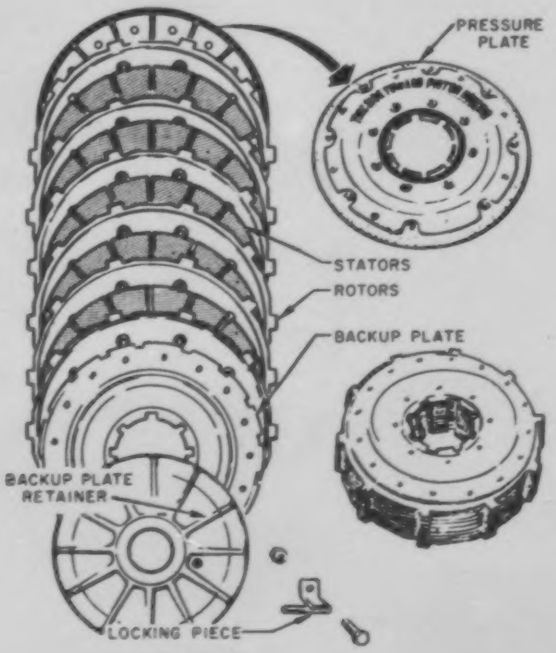
215.105
Figure 7-32.—Checking heat stacks—multiple disc brake.

the overall dimension of the heat stack is below the permitted limit. This does not necessarily condemn the entire heat stack. The individual items of the heat stack may be removed and measured for allowable wear limits as prescribed in the *Maintenance Instructions Manual.* If the red line does not appear behind the slide, the heat stack still has a usable amount of lining and is considered serviceable.

An out of limits heat stack assembly can be made serviceable by replacing rotors, stators, pressure plate, and/or backup plate as necessary. The heat stack may be removed from the aircraft and replaced without jacking the aircraft. Before performing maintenance on the brake, check to determine if the wheels or brakes are hot. Figure 7-33 illustrates the complete heat stack assembly with its pressure plate and backup retainer plate. Remove the locking piece from the backup plate retainer. Remove the backup plate, using the special tool illustrated in figure 7-30 if necessary. Remove the remaining heat stack assembly from the splined torque shaft by sliding the items outboard. Extra care should be taken when handling the pressure plate to prevent damage to attached heat shield material.

The thickness of the lining material on the rotors must not be less than 0.025-inch average. Cracks extending from the relief slots toward the outside diameter of the rotor are not cause for rejection and replacmeent, unless there are more than three cracks in the same rotor or the cracks are in adjacent slots, or if one crack extends completely through to the outside diameter of the rotor. The rotor must also be replaced when the outside diameter across the lugs becomes less than the measurement specified in the MIM and when patches of the lining on the rotor have crumbled away over 3/8 inch from an edge. Rivet head score marks on the lining are not considered detrimental.

The stators and the thin discs riveted to the pressure and backup plates must be replaced if

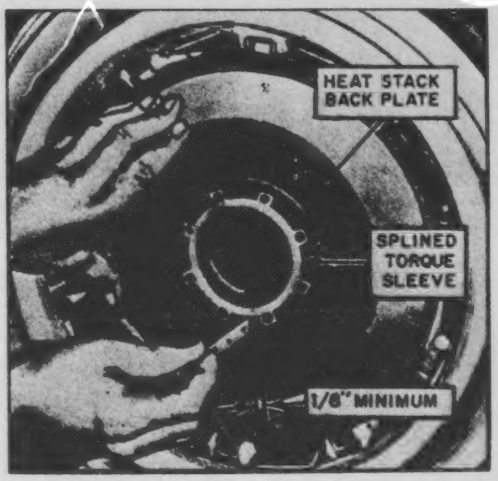


216.111
Figure 7-33.—Heat stack assembly.

cracks are present and extend from the relief slot over 1/4 inch towards the inside diameter, or if the cracks through the disc are present on adjacent slots.

Before installing the heat stack, ensure that the area around the annular piston is clean. Also check to ensure that the bleeder valve is open and the retractor plate is fully retracted. Figure 7-31 illustrates the method used to determine whether the retractor plate is fully retracted. The straightedge is placed across the end of the splined torque sleeve, and the distance from the straightedge to the outboard edge of the retractor plate is measured. The measurement should read from 3 29/32 to 4.0 inches. Take the reading in four different places 90 degrees apart. The difference between the readings should not exceed 1/32 inch. If the dimensions cannot be met, the brake assembly should be replaced, as this could indicate either a warped retractor plate or a cocked annular piston.

If the retractor plate is within limitations, install the pressure plate on the torque shaft with the heat shield material facing inboard and the thin disc facing the heat stack. Install the rotors and stators alternately over the splined sleeve, finishing up with a rotor. Before installing the backup plate retainer, push the heat stack inboard against the retractor plate and measure the distance from the end of the torque sleeve to the outboard face of the backup plate, at the key slots as illustrated in figure 7-34. This distance should be a minimum of 1/8 inch. If the dimension is less than 1/8 inch, check for warped discs or improper position of the retractor plate. If the dimension is within limits, install the backup plate retainer. Tighten with the special tool as specified in the previous section on backup plate adjustment. Apply the brakes two or three times and again retighten the retainer. Adjust the retainer as specified earlier and install the locking piece. Recheck the heat stack thickness, using the gage as illustrated in figure 7-32.

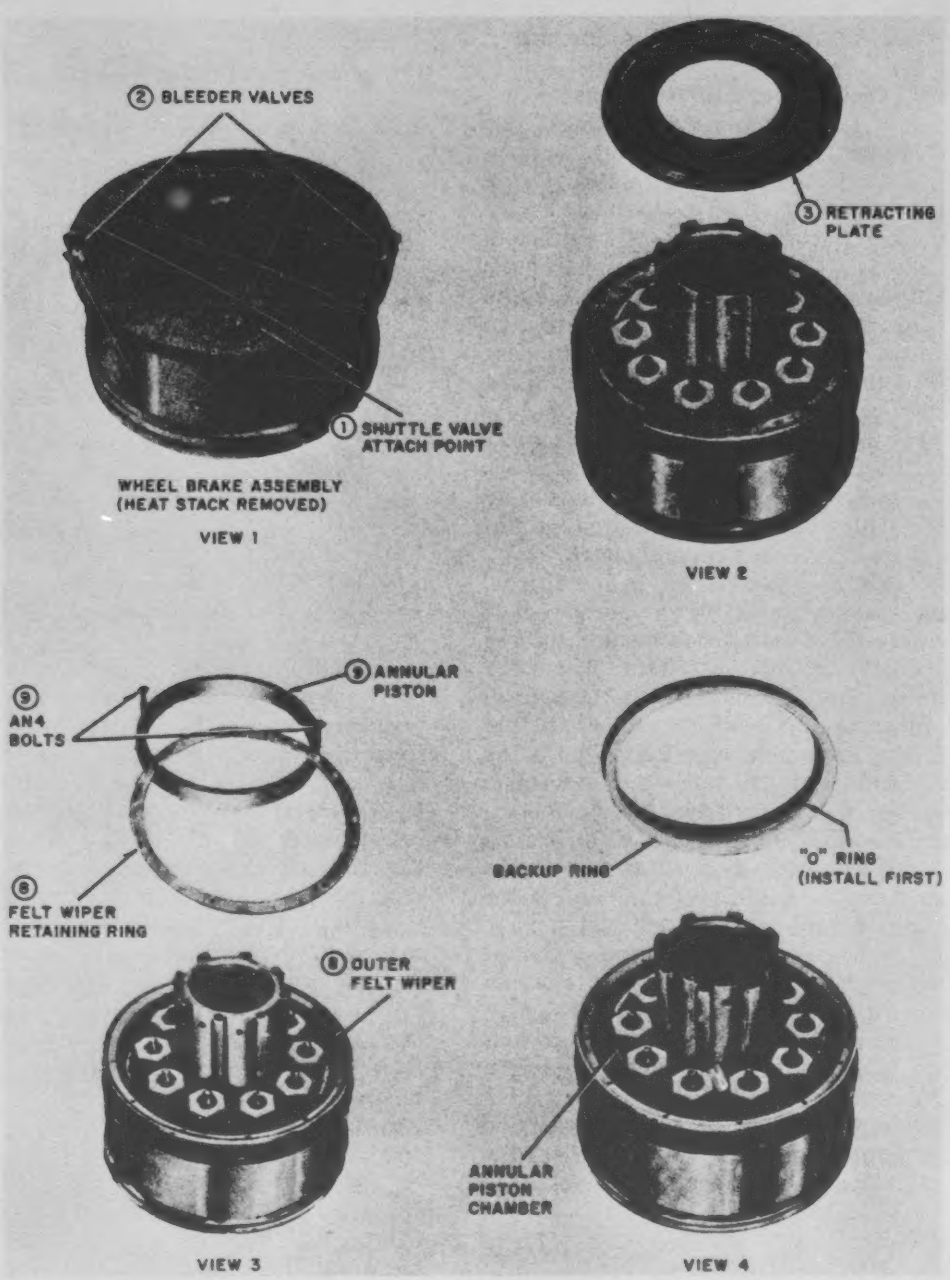


216.112

Figure 7-34.–Check for warped disc/proper retractor plate position.

INTERMEDIATE MAINTENANCE.–An intermediate level maintenance repair kit is available to accommodate repair of the cylinder portion of the brake assembly. The brake is disassembled by first cutting the lockwire and removing the bearing carrier. Next, remove the two bleeder valves and O-rings (see view 1, figure 7-35). Remove the cotter pins, nuts, and washers, securing the retracting plate to the retracting springs (view 2). These nuts should only be fingertight. Remove the retracting plate. Next, remove the screws securing the annular piston outer felt wiper retaining ring. Remove the felt wiper to prevent its damage during reinstallation of the annular piston. Install two bolts in the tapped holes on the upper surface of the annular piston as shown in view 3 and carefully remove the piston by pulling alternately on the bolts. The teflon backup ring and O-ring can now be removed by applying approximately 5 psi to one of the bleeder ports. Exercise care in case the teflon ring has become set in the groove and offers resistance. Discard the O-ring and backup ring.

Clean all removed parts, including the felt wiper, in Stoddard solvent and dry with filtered, low-pressure air to remove loose dirt and moisture. Use a clean, lint-free cloth and wipe the annular piston chamber clean. Ensure that all threads are clean and orifices are unobstructed. Check the surfaces of the annular piston and the piston chamber for damages, such as scoring or scratches. Minor scratches may be


② BLEEDER VALVES
③ RETRACTING PLATE
① SHUTTLE VALVE ATTACH POINT
WHEEL BRAKE ASSEMBLY (HEAT STACK REMOVED)
VIEW 1
VIEW 2
⑨ ANNULAR PISTON
⑤ AN4 BOLTS
⑥ FELT WIPER RETAINING RING
⑧ OUTER FELT WIPER
BACKUP RING
"O" RING (INSTALL FIRST)
ANNULAR PISTON CHAMBER
VIEW 3
VIEW 4

216.113

Figure 7-35.—Intermediate repair steps—multiple disc brake.

removed with abrasive cloth. Ensure that all abrasive materials are removed to prevent contamination of the assembly following reassembly.

Prior to reassembly, apply a light coat of hydraulic fluid to each new O-ring and backup ring. Saturate the felt wiper with a light grade machine oil. Apply antiseize compound to all threaded parts to reduce galling and prevent corrosion. Apply a thin coating of hydraulic fluid to all other parts to facilitate reassembly.

Install the O-ring in the annular piston chamber (view 4) and place the teflon backup ring over the O-ring with the cupped side fitting over the O-ring. Install the annular piston in the piston chamber. Position the piston outer felt wiper around the top edge of the piston and secure in place with the retaining ring and attaching screws. Install the retracting plate over the bolts of the retractor assemblies. Tighten the nuts fingertight and install cotter pins. Install the bleeder valves, using new O-rings.

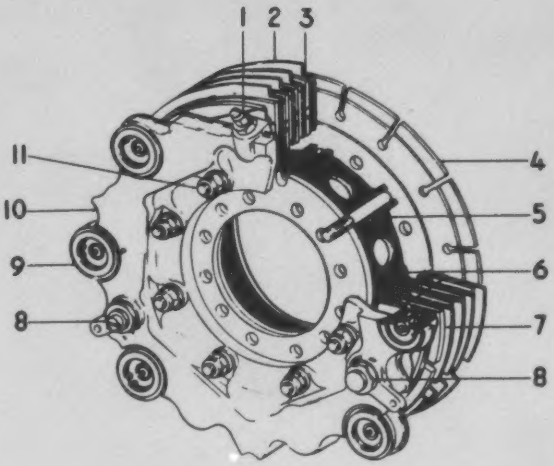
The completely reassembled brake assembly must be tested following repair. Connect the brake assembly to a hydraulic pressure source. With the brake assembly in the vertical position, apply 200 psi to the pressure inlet and bleed the assembly through the bleeder valves. Apply 3,000-psi hydraulic pressure and hold for 5 minutes. Check for leakage at the bleeder valves, and from the area underneath the retracting plate. If the brake is not to be installed immediately, fill the brake with preservative hydraulic fluid and cap all openings to prevent contamination.

TRIMETALLIC DISC BRAKES

Trimetallic disc type brakes are utilized on several late model aircraft including the A-7A, EA-6B, and the E-2A. They operate on the same basic principle as the previously discussed multiple disc brakes. Figures 7-36 and 7-37 illustrate a typical trimetallic brake assembly.

Description

The trimetallic brake assembly consists essentially of a brake housing subassembly, a keyed torque tube and torque tube spacer, a housing back plate, stationary and rotating discs, and a pressure plate subassembly.



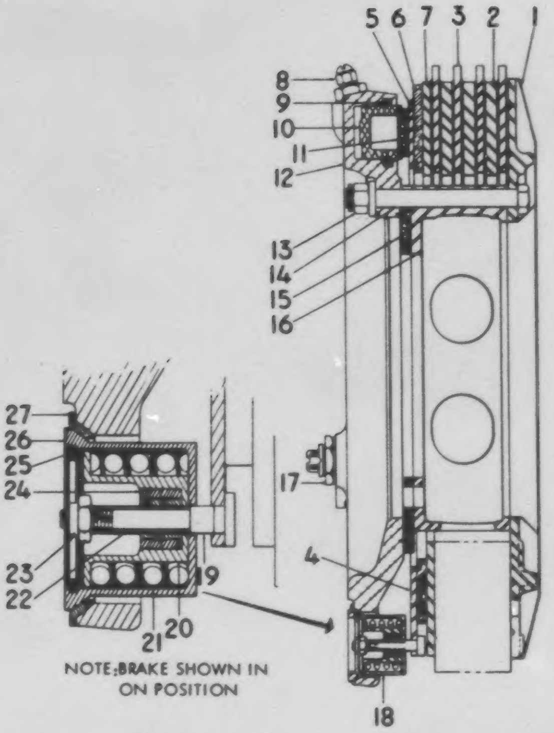
1. Bleeder valve.
2. Rotating disc.
3. Stationary disc.
4. Housing back plate.
5. Keyed torque tube.
6. Torque tube spacer.
7. Pressure plate subassembly.
8. Brake inlet port.
9. Self-adjusting mechanism.
10. Brake housing subassembly.
11. Brake assembling bolt.

216.114

Figure 7-36.—Trimetallic brake assembly.

The brake housing subassembly, keyed torque tube and spacer, and the housing back plate are bolted together to form the basic brake assembly. The remaining components of the brake assembly are mounted over the keyed torque tube and between the brake housing and the housing back plate. The metallic-faced rotating discs have keyways which engage drive keys in the wheel so that they rotate with the wheel.

The rotating discs are separated by the stationary discs, which are keyed to the torque tube. The mating surfaces of these rotating and stationary discs constitute the major friction braking surfaces of the brake. Additional friction surfaces exist between the outer face of one rotating disc and the housing back plate and



NOTE: BRAKE SHOWN IN ON POSITION

1. Housing back plate.
2. Stationary discs.
3. Rotating discs.
4. Pressure plate subassembly.
5. Pressure plate.
6. Wear plate insulator.
7. Wear plate.
8. Bleeder valve.
9. O-ring and backup ring.
10. Piston.
11. Piston insulator.
12. Brake housing subassembly.
13. Self-locking nut.
14. Brake assembling bolt.
15. Torque tube spacer.
16. Keyed torque tube.
17. Inlet bushing.
18. Self-adjusting mechanism.
19. Self-adjusting pin.
20. Return-spring guide.
21. Return spring.
22. Self-adjusting pin tube.
23. Self-locking nut.
24. Split collar grips.
25. Retaining ring.
26. Spring housing.
27. Spring housing bushing.

216.115

Figure 7-37.—Trimetallic brake assembly—cross section.

between the outer face of the rotating disc at the opposite end and the pressure plate subassembly.

The pressure plate subassembly consists of the pressure plate, a replaceable wear plate, and a wear plate insulator. These three parts are riveted together. The pressure plate serves as a seat for the self-adjusting pins of the self-adjusting mechanism and rests against the insulators installed in the outer ends of the brake pistons. It is the component through which force is directly transmitted during application and release of the brakes. The wear plate is keyed to the torque tube to prevent rotation of the complete subassembly and serves as the friction surface for the outer face of the adjacent rotating disc. The wear plate insulator prevents brake heat from being transferred to the pressure plate and the brake pistons.

The brake pistons transmit hydraulic pressure through the pressure plate subassembly to the brake discs. Standard O-rings and backup rings around each piston prevent hydraulic fluid leakage and entry of contaminants. The pistons are further protected against heat transfer from the pressure plate subassembly by individual insulators installed in the ends of each piston where it contacts the pressure plate.

Self-adjusting mechanisms are located around the brake housing. They accomplish normal release of the brake and provide a continuing adjustment action to compensate for brake wear. Each mechanism consists of a self-adjusting pin, a spring housing and bushing, a return spring guide, a retaining ring, a grip and tube subassembly, and self-locking nut. The grip and tube subassembly mounts over the self-locking pin with the grips being installed firmly on the tube. As disc wear occurs, automatic adjustment is provided by movement of the adjusting pins through the split collar grips. The retaining ring inside the spring housing serves as a stop and a retainer for the spring guide which, in turn, holds the return spring in position. The head of the self-adjusting pin engages the pressure plate subassembly to facilitate brake release when pressure is removed.

Operation

When the landing gear wheel is rotating, the metallic-faced rotating discs of the brake assembly rotate freely between the stationary steel discs. When pressure is applied to the brake assembly pistons, the rotating and stationary discs are forced together, creating friction between their surfaces. The amount of hydraulic pressure applied to the brake pistons is controlled by the aircraft's brake metering system in response to the operation of the brake pedals. Braking action applied to the wheel brake is proportional to the pressure exerted on the brake pedal.

Pressure applied to the brake actuates all of the pistons within the brake housing. These pistons in turn force the pressure plate subassembly laterally against the discs and against the housing back plate. As the pressure is applied and the brake starts to actuate, the lateral movement of the pressure plate subassembly pulls the self-adjusting pins, the split collar grip and tube subassemblies, and the return spring guides against the return springs, compressing them until the spring guides bottom in the housings. When the hydraulic pressure is relieved, the return spring mechanisms, acting through the heads of the self-adjusting pins, pull the pressure plate subassembly back to the released position. The pistons also return to their deactuated positions. The extent of the return motion is limited by engagement of the spring guides with the retaining ring stops inside the spring housing.

As the disc wear, the self-adjusting pins and tubes are pulled through the split collar grips by the force exerted on the pressure plate by the pistons. This small movement of the adjusting pins and tubes, relative to the grips, is equivalent to the combined wear of all the discs. When pressure is removed from the brake, the return springs return the pressure plate and the brake pistons to the designed preset clearance and maintain a constant displacement.

Maintenance

Intermediate maintenance of the trimetallic brake assembly consists of disassembly, cleaning and inspection, cure date sealing devices and wear pad replacement as necessary, reassembly, and testing.

DISASSEMBLY.–Place the brake assembly with the brake housing down and remove the brake housing bolts. Remove the backing plate and all discs from the torque tube, then remove the torque tube. Turn the brake over and remove the self-locking nuts to release the return pins. Remove the tube and grip assemblies, pressure plate, and the remaining return spring parts. The tube and grip assemblies should not be disassembled. If they require replacement, replace the complete assembly as a unit.

The piston insulator is removed from the pistons and the pistons removed from the brake housing by threading a return pin into the threaded hole in the piston and pulling slowly. Exercise care to avoid damage to the seal groove and cylinder walls. Remove the bleed valve assembly and the brake inlet plug assembly.

CLEANING AND INSPECTION.–Dust and loose grit are removed using low-pressure air, then all parts are cleaned in a suitable solvent and dried with a clean, lint-free cloth.

All metal parts are visually inspected for cracks, wear, or other apparent damage as specified in the Intermediate Repair section of the *Maintenance Instructions Manual.* Some parts may require inspection by one of the nondestructive methods described in chapter 5. The return spring is inspected for proper resilience. The amount of force required to move the grips on each tube and grip assembly is checked, using a special tube and grip tester.

The rotating disc is inspected for cracks, distortion, and thickness. The disc must be replaced if it is worn below 0.2-inch thickness, if it is cracked, or if the friction mix is worn unevenly. The friction mix may be pitted up to 1/2 square inch in any segment.

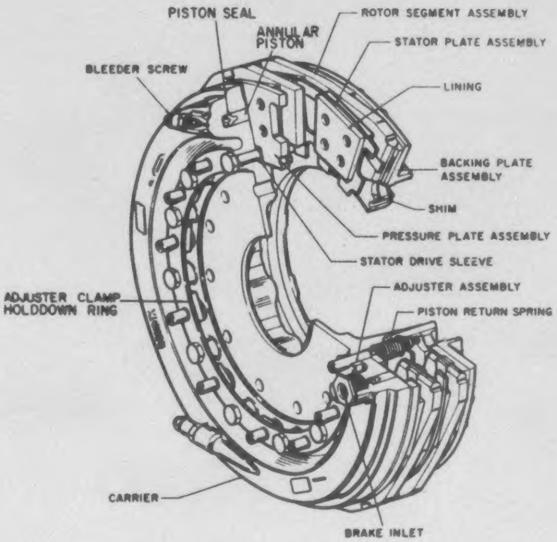
The stationary disc is inspected for cracks and thickness. If the minimum thickness is less than 0.3-inch or the disc is cracked, it should be replaced.

The back plate and pressure plate should be replaced if they are cracked. If the wear pads are worn to less than 0.088-inch thick, they should be replaced.

WEAR PAD REPLACEMENT.–Wear pad replacement on the pressure plate and the backing plate is authorized. Drill out rivets securing the worn pads and discard the worn pads. Check the plates for carcks, deformation, and rivet hole elongation. Using a standard squeeze rivet machine, rivet the replacement wear pads to the plates using the type of rivet specified in the applicable MIM. The rivet bucktail must be below the surface of the wear pad. Rivets with more than one crack visible in the bucktail or with less than 50% of the circumference of the formed head not being flush with the sides of the countersunk area are not acceptable. The new wear pads must be surface ground to 0.100-inch thickness and should be flat within 0.010-inch after grinding. The reworked plates should be vapor degreased to remove all oil and grinding material. The dried plates should be wrapped in clean, heavy paper for protection until they are replaced in the brake assembly.

REASSEMBLY.–Reassembly of the trimetallic brake is essentially in the reverse order of disassembly. The packings, retainers, cylinder walls, and other contacting surfaces within the brake housing should be lubricated with a light coating of MIL-G-81322, general purpose aircraft grease prior to reassembly. MIL-G-6032B grease is applied to the piston side of the piston insulators. Lubricate the brake housing bolts and the contacting surfaces of the boltheads with antiseize compound. The coating of these bolts and the contacting surface of the boltheads followed by torquing is referred to in some MIMs as "Lubtork."

TESTING.–The reassembled trimetallic brake must be tested to ensure the quality of maintenance. Connect the brake assembly to a hydraulic test stand and apply 25 psi to the inlet port. Open the bleeder valve until air-free fluid flows from the valve. Increase the pressure to 1,000 psi for 2 minutes and check for leaks. Relieve and reapply 1,000 psi several times, then release the pressure slowly to 90 psi. Holding the 90-psi pressure, measure the clearance between the pressure plate and the first rotating disc. Minimum clearance must be 0.065 in. If used discs were reinstalled, check for proper rotation. Secure the test stand, disconnect the brake, and plug the inlet port to prevent contamination.



216.116

Figure 7-38.—Segmented rotor brake—cutaway view.

SEGMENTED ROTOR BRAKES

Figure 7-38 provides a cutaway view of the segmented rotor brake. As can be seen, the brake is very similar to the multiple disc brake discussed earlier in this section. The major difference is the segmented rotors.

The carrier serves as a housing for the hydraulic actuating piston, the return springs, and the automatic adjusters. Structurally, the carrier has two main functions. It is designed to react within deflection limits against the axial loads introduced to the brake by the hydraulic pressure acting on the piston, and it absorbs and transmits all brake torque to the strut brake flange. There are two bleeder valves on the carrier so that the brake may be mounted on either the left-hand or right-hand strut. The carrier must be installed on the aircraft with a bleeder port at the top of the brake to ensure proper bleeding of air from the brake.

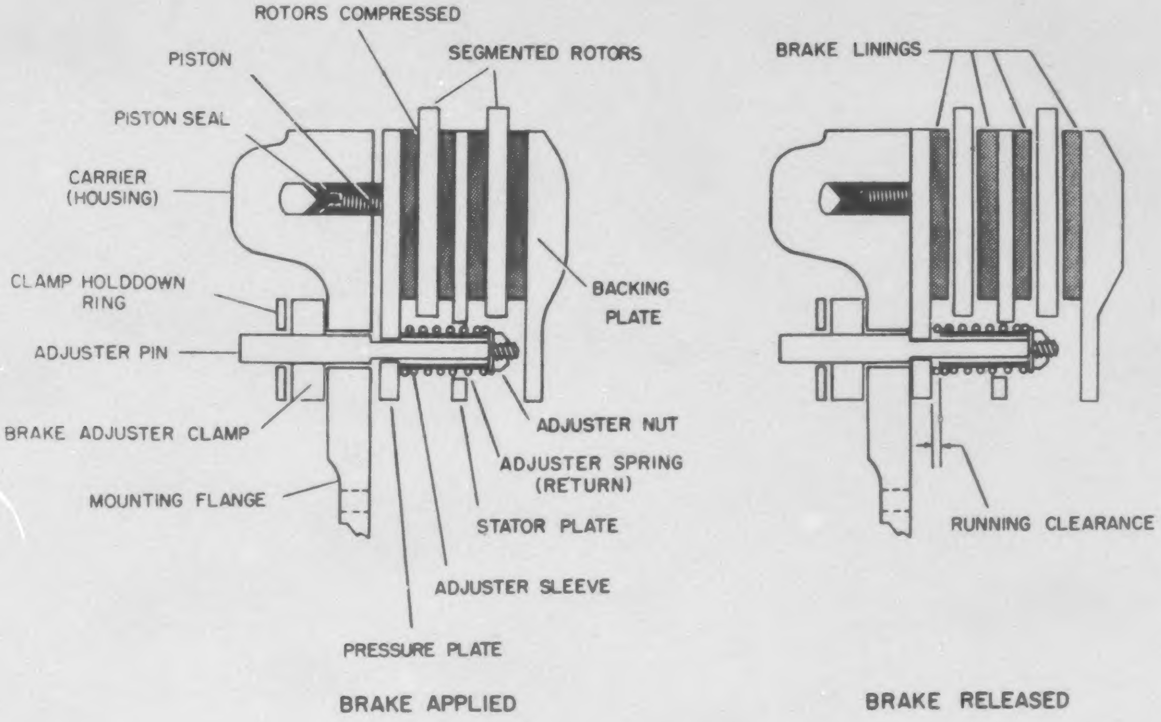
The pressure plate transmits the axial clamping force from the actuating piston to the brake disc elements. Springs on the adjuster pins which are attached to the pressure plate return the piston and pressure plate. This action takes place when the brake pressure is released to provide running clearance between the running and nonrunning elements of the brake. The inside diameter of the pressure plate is splined to index with and transfer brake torque to the stator drive sleeves. The pressure plate has linings secured to the face adjacent to the first rotor assembly.

The rotor assemblies are the primary heat sink of the brake. The rotors are notched on the outside diameter to engage the rotor drive keys of the wheel assembly and thus rotate with the wheel. The use of a segmented rotor design virtually eliminates the problem of rotor warpage which is prevalent with thermally stressed solid discs. This design (segmentation of the rotor) increases safety, efficiency, and service life of the brake assembly.

Mounted between the segmented rotor assemblies is a stator plate. The stator plate is a nonrotating plate and has linings riveted to both sides. The linings are in the form of multiple blocks, separated to aid in the dissipation of heat. (See fig. 7-38.)

The backing plate is a nonrotating plate with linings riveted on the side adjacent to the second segmented rotor assembly. This plate receives the ultimate hydraulic force resulting from brake application. Rolled pins pressed into the torque tube of the carrier mate with the backing plate to absorb the torque loads imposed during brake applications.

The brake illustrated in figure 7-38 has friction-type automatic brake adjusters to compensate for lining wear and maintain a uniform running clearance between braking surfaces as they wear. The running clearance is the free play distance of the adjuster sleeve between the pressure plate and the adjusting nut on the end of the adjuster pin. (See fig. 7-39.)


ROTORS COMPRESSED
PISTON
SEGMENTED ROTORS
PISTON SEAL
CARRIER (HOUSING)
CLAMP HOLDDOWN RING
ADJUSTER PIN
BACKING PLATE
BRAKE ADJUSTER CLAMP
ADJUSTER NUT
ADJUSTER SPRING (RETURN)
MOUNTING FLANGE
STATOR PLATE
ADJUSTER SLEEVE
PRESSURE PLATE
BRAKE APPLIED
BRAKE LININGS
RUNNING CLEARANCE
BRAKE RELEASED

216.117

Figure 7-39.—Segmented rotor brake—adjustment schematic.

Proper functioning of the automatic adjuster is dependent upon the correct friction between the adjuster pin and the adjuster clamp. If the clamp-to-pin friction is too great, it is possible that the pin will not slide through the clamp as the lining wears, eventually resulting in a loss of braking action. If the friction is too little, the return springs (on brake release) may slide the pins through the clamps, resulting in a loss of the automatic adjustment feature.

During brake application, the pressure plate moves toward the rotors, compressing the return spring. As piston travel continues and as the pressure plate moves farther, the lining comes in contact with the rotor segments. As the linings wear, the pressure plate continues to move and eventually comes into direct contact with the adjuster sleeve, which results in no further force being applied to the spring. Additional travel of the pressure plate (resulting from lining wear) forces the adjuster pins to slide through the adjuster clamps.

When hydraulic pressure in the brake is released, the return spring forces the pressure plate to return until it bottoms on a shoulder on the adjuster pin. As this cycle is repeated during brake application and release, the adjuster pin will advance through the adjuster clamp due to lining wear, but the running clearance will remain constant.

Other segmented rotor type brake assemblies use a hydraulic brake adjuster to compensate for wear. This adjuster is similar to the one illustrated in figure 7-28 and discussed previously in this section.

Maintenance

When the adjuster pin recession indicates that the lining wear has progressed to the maximum allowable, the brake must be removed and relined or replaced. The linings and cure-date sealing devices are normally replaced at the intermediate level of maintenance. A list of the tools and instructions for performing the work is provided in the Intermediate Maintenance section of the MIM for the aircraft concerned or in the 03 publication for the specific brake.

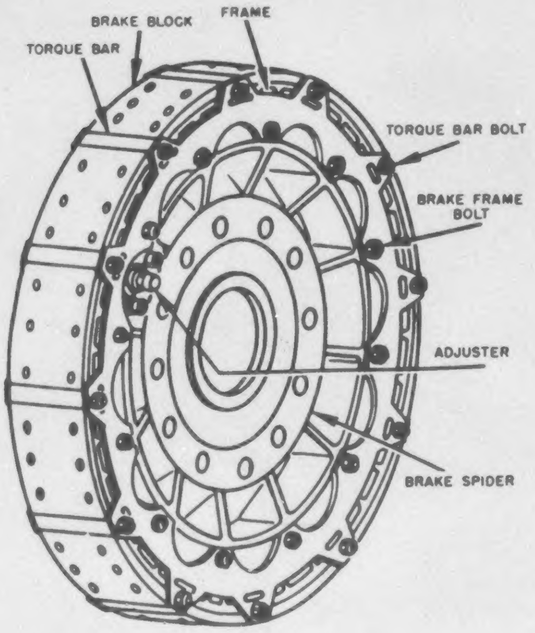
After new linings have been installed (or upon removal of shims), the running clearance must be readjusted. To adjust the running clearance, the adjuster nuts are tightened until the adjuster sleeves bottom against the pressure plate. The adjuster nuts are then backed off the prescribed number of turns. This clearance remains constant during wear of the linings. As the brake linings wear, the adjuster pins move through the adjuster clamps farther and farther. This is allowed to continue until the visible portion of any one pin has diminished to the dimension range applicable to that particular brake.

It is extremely important that the automatic adjusters be cared for diligently so that the friction setting between the pin and the clamp remains undisturbed. Anything that will affect the friction coefficient between the pin and clamp will adversely affect the brake running clearance. Accordingly, do not paint, apply oil or grease, or in any way treat or mistreat these parts.

Due to the similarity between the maintenance procedures for the segmented rotor-type brake and those previously discussed for multiple disc and trimetallic disc brakes, no further maintenance coverage is provided in this training manual.

EXPANDER TUBE-TYPE BRAKES

Figure 7-40 provides a typical example of an expander tube brake assembly. The brake operates on low pressure with 360 degrees of braking surface being applied to the brake drum assembly. A complete description of the brake assembly and its operation is provided in the *AMH 3 & 2 Rate Training Manual*, and no further coverage is provided in this chapter.



215.116

Figure 7-40.—Assembled expander tube brake assembly.

The wheel and brake drum assembly illustrated in figure 7-41 is used with a dual set of expander tube brake assemblies. The two wheel halves are factory balanced, and the light area of the casting is designated by a letter "L" stamped on the rim.

Each brake drum is also balanced, and a letter "L" is stamped on the rim of the drum to indicate the center of the light area. The drums are installed on the wheel casting with their L markings opposite the L markings on the respective wheel halves. If necessary, the wheel and brake drum assembly may be rebalanced to the tolerances specified in the applicable Maintenance Instructions Manual by adding weights to the brake drum bolts. If, during maintenance, it is necessary to remove the weights or the brake drums, the weights and the drum must be installed in their proper relationship to the wheel halves, and the wheel assembly should be rechecked for proper balance prior to mounting the tire and tube.

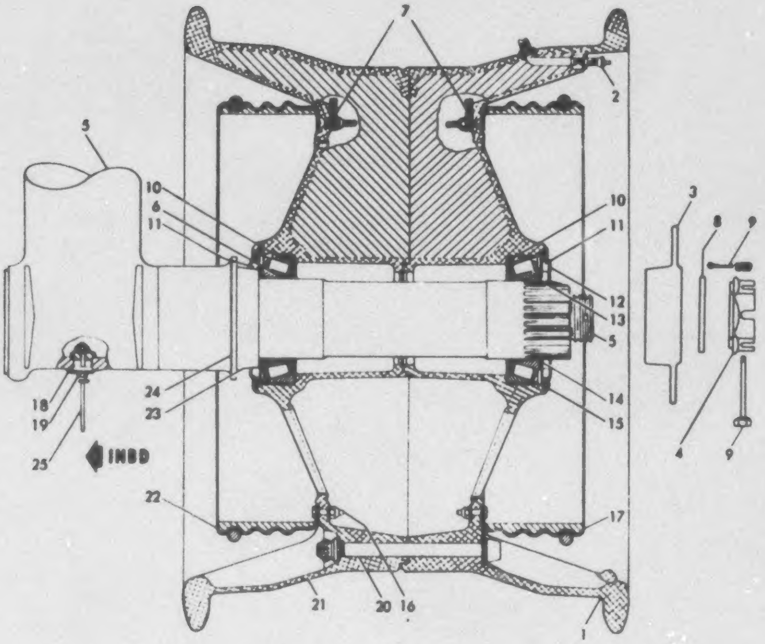
The brake drum is composed of an inner surface of cast iron enclosed in a steel shell. The cast iron surface of the brake drum will develop transverse, circumferential, shrinkage, and heat cracks as the drum wears. The drum should be replaced when any crack extends through the cast iron to the steel shell.

Installation of a new drum on the wheel casting consists of cleaning the wheel casting area of contact, then painting the contact area with zinc chromate primer. Next, the new drum is heated in boiling water to provide a free assembly of the drum on the wheel. When the drum is hot, quickly mount it on the wheel half and line up the mounting holes. The drum should fit snug but not require excessive torque on the mounting bolts to cause it to seat. If the fit is too snug the internal diameter can be manually filed as necessary to provide a heated drum snug fit. Do not try to assemble the drum on the wheel halves in the cold condition. The excessive force required to seat the drum could result in damage to the bolts and wheel casting.

Intermediate maintenance of the expander tube brake assembly consists of disassembly of the brake and adjuster, and cleaning, inspection, repair and replacement of brake blocks, expander tube, defective retracting springs, packings, and all other defective parts that would affect the operation of the brake, and testing to verify proper operation.

On dual installations, if the expander tube in one assembly is replaced with a new tube, both must be replaced or uneven braking could occur due to the difference in tube strength.

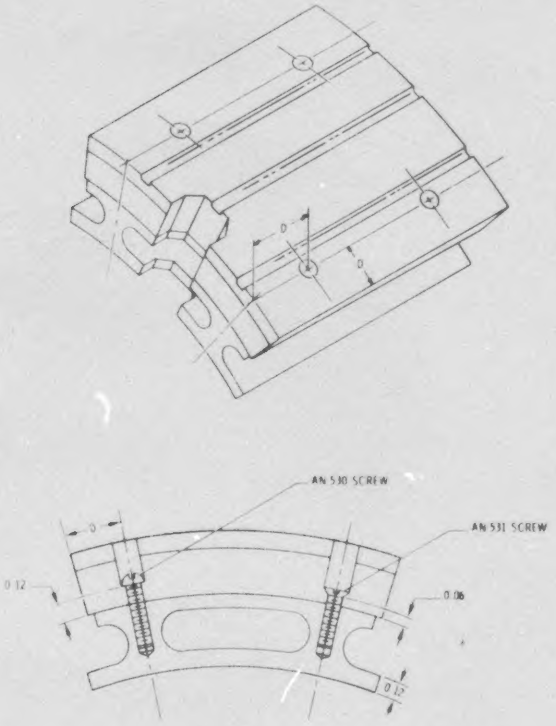
Bonding failure between the lining and the shoe portion of the brake block may be repaired by placing the lining on the shoe in its original position and drilling holes in the lining and the shoe to accommodate the installation of self-tapping metal screws. The lining must be counterbored to a specified depth so that the screw head will be recessed and not contact the brake drum. (See fig. 7-42.)



1. Outboard wheel casting.
2. Air valve.
3. Outboard brake plate
4. Axle nut.
5. Shock strut piston-axle.
6. Inboard bearing cone.
7. Wheel balance weights.
8. Axle washer.
9. Lock bolt, nut, cotter pin.
10. Bearing cup (2 req).
11. Grease retainer felt (2 req).
12. Outer felt retainer (2 req).
13. Outboard bearing cone.
14. Inner felt retainer (2 req).
15. Lockring (2 req).
16. Brake drum attachment bolt, washer, nut (32 each req).
17. Outboard brake drum.
18. Wire holder plug.
19. Wire holder nut.
20. Wheel casting tie bolt (8 req), washer (16 req), nut (8 req).
21. Inboard wheel casting.
22. Inboard brake drum.
23. Collar.
24. Inboard brake plate.
25. Static wire assembly.

216.118

Figure 7-41.—Expander tube-wheel and brake drum assembly.



216.119

Figure 7-42.–Repair of brake blocks.

If it is necessary to replace an individual block and lining assembly, the remaining service life of the other block assemblies will determine whether only one or all the brake blocks should be changed. When a new block is installed with old ones, the new lining thickness should be reduced to that of the old.

Complete intermediate level maintenance procedures are provided in the Intermediate Maintenance section of the applicable aircraft Maintenance Instructions Manual and/or the appropriate 03 Manual.

CHAPTER 8

LANDING GEAR MAINTENANCE

Most present day aircraft are equipped with three-point retractable landing gear. Each main landing gear assembly usually consists of a conventional recoil strut, a wheel brake assembly, and a wheel and tire assembly. The majority of present day aircraft feature a nose gear system rather than the older tailwheel system; however, there are still some aircraft in service equipped with the latter. Some aircraft which feature a tricycle-type landing gear system also have a small tailwheel or tail skag because of the critical limits of the center of gravity when on the deck or the possibility of aft fuselage contact during landing and takeoff angles.

In this chapter, discussion of the landing gear includes the operation of a system, emergency extension methods, catapulting and nose steering mechanisms, arresting gear mechanisms, and maintenance practices associated with maintaining the landing gear.

The T-39 system is discussed first.

LANDING GEAR SYSTEM (T-39)

The landing gear recoil struts on the T-39D are of the air-and-oil recoil absorber type, containing a specific amount of compressed nitrogen and hydraulic fluid. Each main gear assembly consists of a recoil strut, a wheel brake assembly, and a wheel and tire assembly. The recoil struts are designed to absorb impact loads during takeoff, landing, taxiing, and braking operations.

The main gear struts consist of an outer cylinder assembly at the upper end and an inner cylinder assembly (oleo) at the lower end. The outer and inner cylinders are connected by torque links at the lower end of the strut assembly. The torque links transmit torque loads from the inner cylinder to the outer cylinder and keep them in alignment. During landing, the impact load telescopes the inner cylinder into the outer cylinder. This moves the metering rod through the orifice, allowing a regulated flow of hydraulic fluid. The impact load upon the strut assembly is absorbed by the flow of hydraulic fluid through the orifice. This lengthens the time required for the impact to reach the airframe structure, resulting in greatly reduced impact forces. The gear is fully retracted into the fuselage and wing and is faired in by wheel and recoil strut fairing doors. Control and sequence functions of the system are accomplished through use of the landing gear control handle and by automatic mechanical actuation of electrical switches attached to the landing gear and wheel fairing doors.

On aircraft changed by Airframes Change 39, the permissible aircraft landing weight is increased to 15,000 pounds. A larger metering pin and a modified orifice support tube are installed in each recoil strut. During taxiing and braking, the loads and the weight of the aircraft are mainly carried by the compressed air in the cylinder assembly. During extension of the strut, snubbing action prevents the weight of the lower strut or inner cylinder assembly from bottoming with excessive force against the inner cylinder support. This is done by forcing the hydraulic fluid through a small orifice. This causes the snubbing action and slows the rate strut extension.

The nose gear assembly consists of a recoil strut, a shimmy damper, and a dual wheel and tire assembly. During landing and before nose gear touchdown, the strut is fully extended. The centering cams in the inner and outer cylinder assemblies are mated, aligning the nosewheels with the direction of the aircraft. The metering rod attached to the inner cylinder protrudes through the orifice of the outer cylinder. During taxiing and braking, the loads and the weight of the aircraft are carried mainly by the air in the outer cylinder assembly. On aircraft changed by Airframe Change 72, a stability augmentation balance weight has been added to the lower end of the recoil strut. Its effect is to increase nose gear system dynamic stability during takeoff and landing conditions.

During nose wheel steering operation, the torque links connected between the inner cylinder assembly and outer cylinder assembly strike a stop attached to the outer cylinder, preventing rotation of the nose wheel beyond 35 degrees left or right. When the aircraft is to be towed, a latch at the forward side of the strut is disengaged allowing the nose wheel to turn beyond 35 degrees left or right.

NORMAL OPERATION

Figure 8-1 is a schematic of the T-39D landing gear system. While you are studying the following operational description, frequent reference to the schematic will aid in understanding the system.

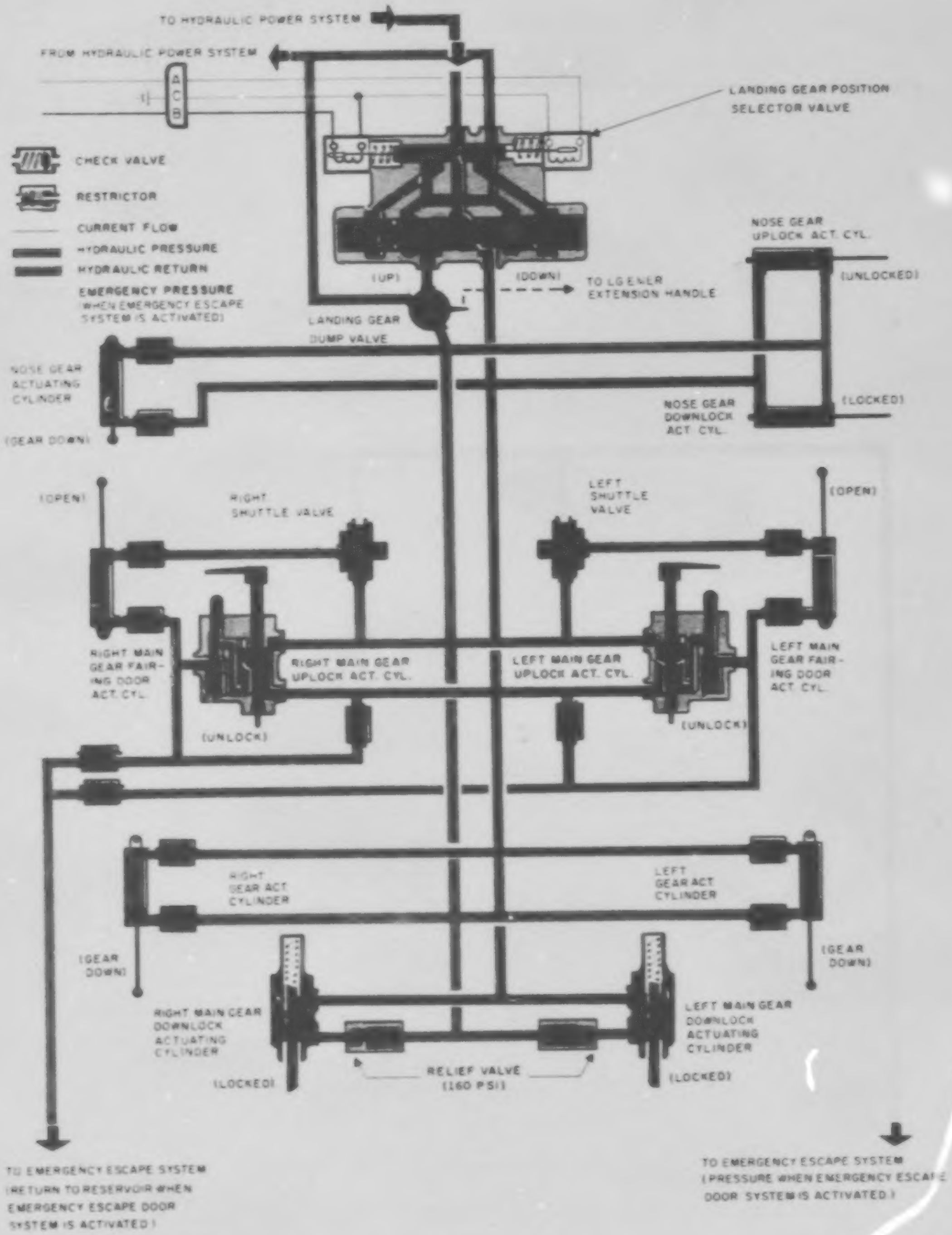
Gear Retraction

When the landing gear control handle is moved to the UP position after takeoff, parallel electrical circuits are completed through the gear uplock switches, and the main gear fairing door uplock switches to the red warning lights in the landing gear control handle. These lights indicate the gear is not in the UP and locked position. Hydraulic pressure is routed through the valve to the unlock side of each gear downlock cylinder and to the lock side of each gear uplock cylinder. As the downlock pin of each landing gear is pulled, the down-and-locked green light for each landing gear goes out and hydraulic pressure begins to retract the gear.

When the nose gear nears the up position, the mechanical linkage attached to the nosewheel fairing doors is cammed by the gear strut toward the closed position. Near the fully retracted position, the gear uplock roller on the strut cam operates the nose gear uplock hook open to allow the hook to pass. As soon as the roller passes the lip of the hook, the bungee returns the hook to the closed position. This secures the gear in the up position. On the main gear the uplock roller on the strut strikes the upper cam face of the main gear uplock hook. This breaks the mechanism from unlocked overcenter, permitting the unlock cylinder to rotate the hook under the uplock roller to the full uplocked overcenter position. When either main gear uplock hook is moved to the locked position, an orifice within each uplock actuating cylinder mechanically opens, allowing return fluid to flow from the main gear fairing door actuating cylinder back through the landing gear position selector valve to the reservoir, permitting the doors to close. When all landing gear and doors are up and locked, the electrical circuit to the red warning light in the gear control handle opens, causing the warning light to go out and indicating all gear and doors are up and locked.

Gear Extension

When the control handle is moved to the DOWN position, the electrical circuit to the gear-down solenoid in the gear position selector valve is completed. This will cause the red warning light in the control handle to come on. If, at this time, either throttle is retarded below 95 percent rpm, or if the airspeed is below 145 knots, or if the altitude is below 10,000 feet, an audible warning sound is heard in the headsets and from the warning horn; and the red light in the control handle will go from steady to flashing. This sound will continue until all gears are down and locked, the warning horn cutout button is depressed, or until both throttles are advanced to 95 percent rpm. The warning light goes out when the gear is down and locked, or the altitude, indicated airspeed, and engine rpm are above limits. Hydraulic pressure is routed to the unlock side of all gear uplock cylinders, to the lock side of all gear downlock cylinders, and to the geardown side of all gear actuating cylinders. Hydraulic pressure is also routed to the door-open side of the main gear wheel fairing doors.


TO HYDRAULIC POWER SYSTEM
FROM HYDRAULIC POWER SYSTEM
A
C
B
LANDING GEAR POSITION SELECTOR VALVE
CHECK VALVE
RESTRICTOR
CURRENT FLOW
HYDRAULIC PRESSURE
HYDRAULIC RETURN
EMERGENCY PRESSURE (WHEN EMERGENCY ESCAPE SYSTEM IS ACTIVATED)
(UP)
(DOWN)
TO LG EMER EXTENSION HANDLE
LANDING GEAR DUMP VALVE
NOSE GEAR UPLOCK ACT. CYL.
(UNLOCKED)
NOSE GEAR ACTUATING CYLINDER
(GEAR DOWN)
NOSE GEAR DOWNLOCK ACT. CYL.
(LOCKED)
(OPEN)
RIGHT SHUTTLE VALVE
LEFT SHUTTLE VALVE
(OPEN)
RIGHT MAIN GEAR FAIRING DOOR ACT. CYL.
RIGHT MAIN GEAR UPLOCK ACT. CYL.
LEFT MAIN GEAR UPLOCK ACT. CYL.
LEFT MAIN GEAR FAIRING DOOR ACT. CYL.
(UNLOCK)
(UNLOCK)
RIGHT GEAR ACT CYLINDER
LEFT GEAR ACT CYLINDER
(GEAR DOWN)
(GEAR DOWN)
RIGHT MAIN GEAR DOWNLOCK ACTUATING CYLINDER
LEFT MAIN GEAR DOWNLOCK ACTUATING CYLINDER
(LOCKED)
RELIEF VALVE (160 PSI)
(LOCKED)
TO EMERGENCY ESCAPE SYSTEM (RETURN TO RESERVOIR WHEN EMERGENCY ESCAPE DOOR SYSTEM IS ACTIVATED)
TO EMERGENCY ESCAPE SYSTEM (PRESSURE WHEN EMERGENCY ESCAPE DOOR SYSTEM IS ACTIVATED)

216.120

Figure 8-1.—Landing gear system—schematic.

Hydraulic pressure applied to the main gear uplock hook actuating cylinders overcomes the overcenter lock mechanisms and rotates the hooks to the unlocked position, unlocking the main gear and strut fairing doors. When hydraulic pressure is applied to the nose gear uplock actuating cylinder, it disengages the gear uplock hook. A cable, attached to the nose gear uplock hook and to the door uplock hook at the forward edge of the door, mechanically unlocks the fairing doors.

All landing gear assemblies are now released from their uplock hooks. When the nose gear nears the down position, the twin downlock pin rides circular cams on the unfolding drag brace. When the gear is fully down, the downlock pins are seated into the locked position by springs. As the main gear nears the down-and-locked position, the side brace ends cam the downlock pins open.

When the gear reaches the full-down position, the spring-loaded downlock pins seat into receivers in the side brace and lock the gear down. With all landing gear assemblies down and locked, an electrical circuit is completed to the green position indicator light, causing the light to glow and indicating the gear is down and locked.

If the main landing gear doors are open and it becomes necessary for crewmembers to exit the aircraft via the emergency escape door, there is a possibility that the doors could present a hazard. When the emergency escape system is operated, hydraulic pressure from the power system opens the speed brake and closes the main landing gear doors. If normal hydraulic pressure is not available, the emergency escape system "D" handle is pulled, causing a gas generator-hydraulic power transmitter to provide pressure to open the speed brake and close the doors. The transmitter is similar to a conventional cylinder-type accumulator except it has a gas generator as an integral part of one end. The transmitter contains 70-cubic inches of fluid. The gas chamber contains a primer, an igniter, and enough propellant grain to displace all the fluid in 3 seconds. The charge is ignited by gas pressure from the initiator cartridge, which is activiated by the action of the "D" handle. A burst-type diaphragm protects the gas chamber of the transmitter from over pressurization. A relief valve in the hydraulic portion of the system protects the hydraulic lines and components.

EMERGENCY EXTENSION

Design requirements for landing gear systems provide for an alternate method of lowering the landing gear in the event the normal system malfunctions.

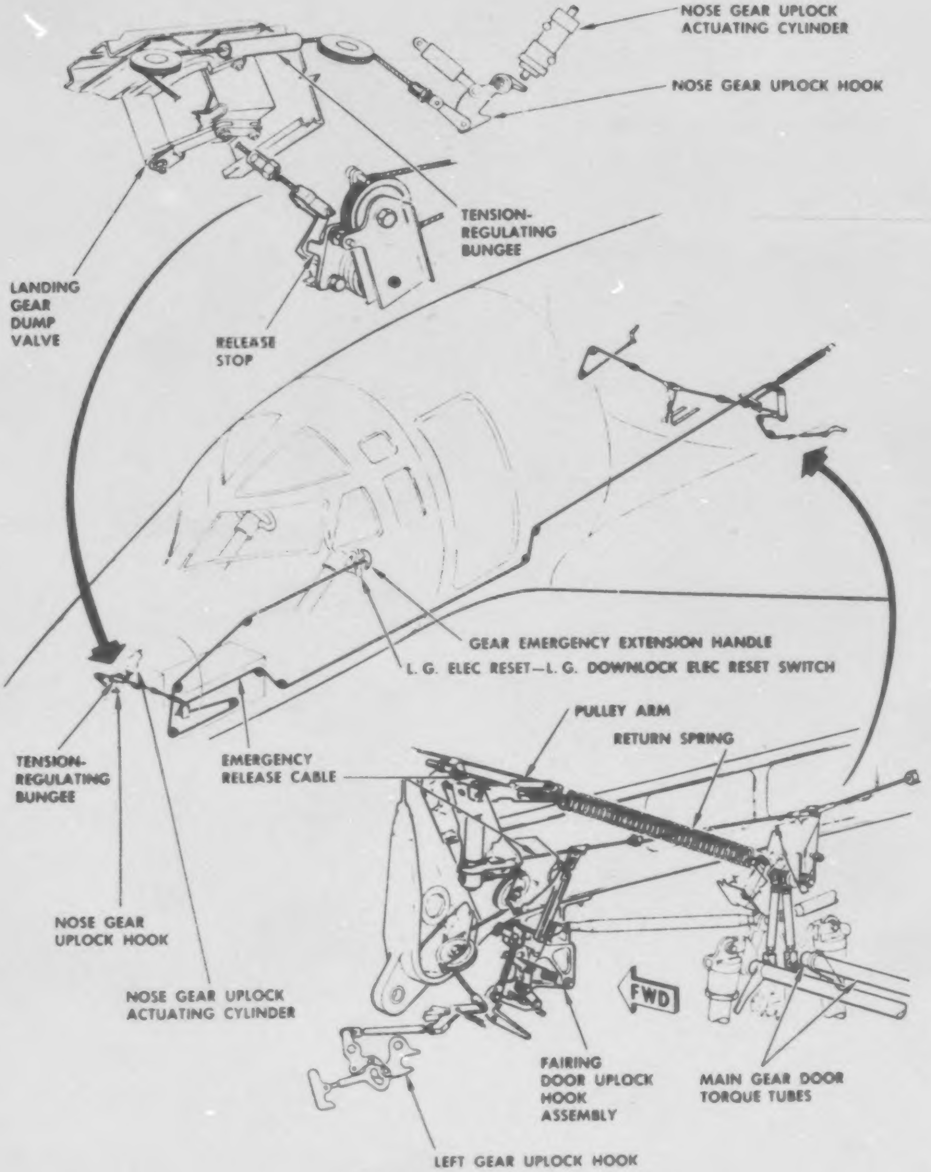
The method used will depend on several factors such as–the weight of the aircraft landing gear, aircraft speed, and landing gear configuration. If the gear extends aft with the airstream and can utilize gravity plus the airstream to force it into the locked position, the emergency system arrangement can be limited to dumping trapped fluid in the normal system and mechanically unlocking the landing gear and door uplocks.

If the gear must extend against the air current, some means of forcing it into the locked position must be utilized. Force may be provided by an auxiliary hydraulic system, a pneumatic system, spring tension or combinations of these means of forcing the gear into the down-and-locked position. Several aircraft manufacturers utilize pneumatic pressure for the nose gear and depend on gravity and air current to pull the main gear into the locked position.

Free Fall Type

The emergency extension system of the T-39, illustrated in figure 8-2, represents a typical free fall arrangement. Emergency extension is accomplished by placing the gear control handle in the DOWN position and pulling the emergency extension handle.

When the emergency handle is pulled, the normal electrical circuitry to the landing gear position selector valve is opened, the fairing door lock hooks and the main gear uplock hooks are mechanically released, and the internal parts in the landing gear dump valve are moved to a dump position. This provides a path for return fluid from the retract side of the actuating cylinder to the return lines, preventing a hydraulic lock. The fairing doors are pushed open as the gear falls.

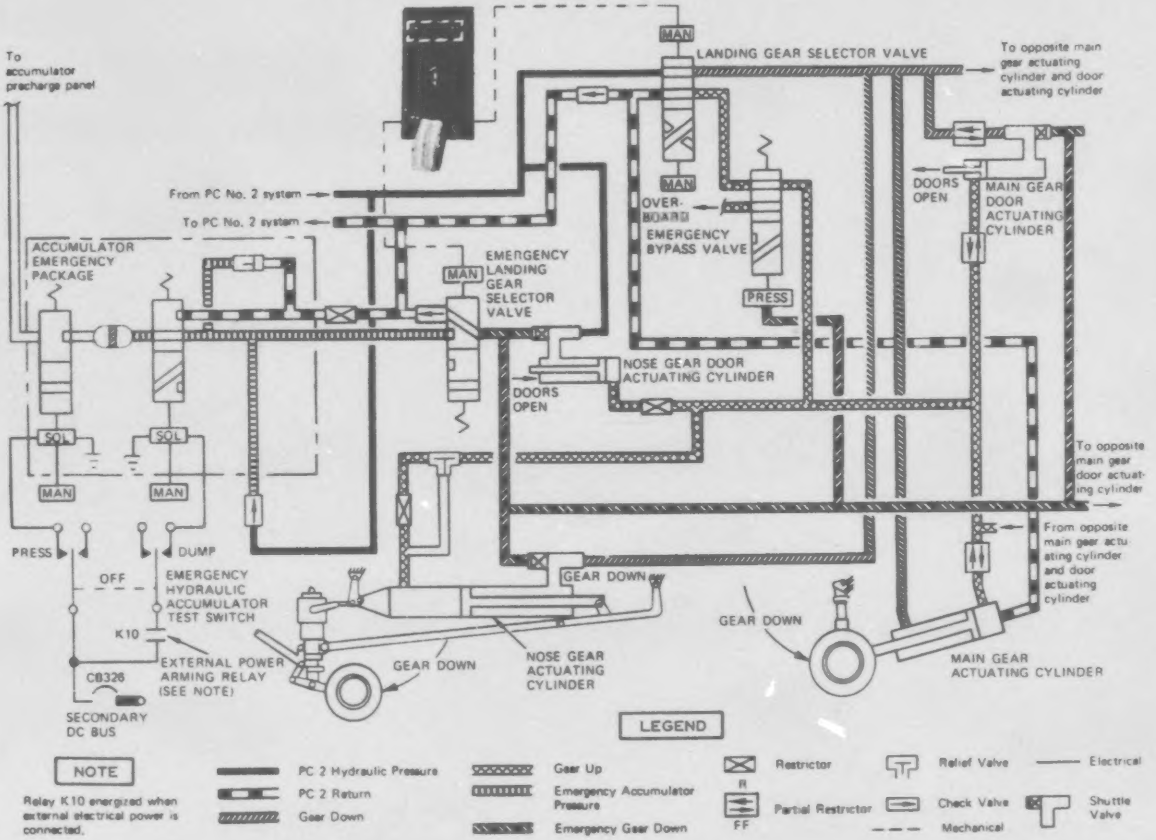

NOSE GEAR UPLOCK ACTUATING CYLINDER
NOSE GEAR UPLOCK HOOK
TENSION-REGULATING BUNGEE
LANDING GEAR DUMP VALVE
RELEASE STOP
GEAR EMERGENCY EXTENSION HANDLE
L. G. ELEC RESET—L. G. DOWNLOCK ELEC RESET SWITCH
PULLEY ARM
RETURN SPRING
TENSION-REGULATING BUNGEE
EMERGENCY RELEASE CABLE
NOSE GEAR UPLOCK HOOK
NOSE GEAR UPLOCK ACTUATING CYLINDER
FWD
FAIRING DOOR UPLOCK HOOK ASSEMBLY
MAIN GEAR DOOR TORQUE TUBES
LEFT GEAR UPLOCK HOOK

216.121

Figure 8-2.—Emergency extension system.

The main gear is extended to the down-and-locked position by gravity with the aid of a bungee on each gear; the nose gear is forced to the down-and-locked position by the airstream when in flight.

The "L.G. ELECT. RESET" switch on the instrument panel below the emergency extension handle must be reset after an emergency extension has been performed, or the landing gear will not retract when the next


To accumulator precharge panel
From PC No. 2 system
To PC No. 2 system
ACCUMULATOR EMERGENCY PACKAGE
SOL
SOL
MAN
MAN
MAN
PRESS
DUMP
OFF
EMERGENCY HYDRAULIC ACCUMULATOR TEST SWITCH
K10
EXTERNAL POWER ARMING RELAY (SEE NOTE)
CB326
SECONDARY DC BUS
EMERGENCY LANDING GEAR SELECTOR VALVE
DOORS OPEN
GEAR DOWN
GEAR DOWN
NOSE GEAR ACTUATING CYLINDER
MAN
LANDING GEAR SELECTOR VALVE
MAN
OVERBOARD
EMERGENCY BYPASS VALVE
PRESS
NOSE GEAR DOOR ACTUATING CYLINDER
To opposite main gear actuating cylinder and door actuating cylinder
DOORS OPEN
MAIN GEAR DOOR ACTUATING CYLINDER
To opposite main gear door actuating cylinder
From opposite main gear actuating cylinder and door actuating cylinder
GEAR DOWN
MAIN GEAR ACTUATING CYLINDER
LEGEND
PC 2 Hydraulic Pressure
PC 2 Return
Gear Down
Gear Up
Emergency Accumulator Pressure
Emergency Gear Down
Restrictor
R
FF
Partial Restrictor
Relief Valve
Check Valve
Mechanical
Electrical
Shuttle Valve

NOTE

Relay K10 energized when external electrical power is connected.

216.122

Figure 8-3.—Landing gear system.

normal retraction of the landing gear is attempted.

Combination Free Fall Blowdown Type

The landing gear system of the A-7, illustrated in figure 8-3, provides an example of a combination emergency extension system. When the P.C. No. 2 hydraulic system fails, emergency extension is provided by an accumulator precharge package. The accumulator is precharged with nitrogen and charged to normal system operating pressure by the P.C. No. 2 hydraulic system. It provides a source of stored energy for a single gear extension cycle.

The gear is extended by placing the control handle in the emergency wheels down position. This opens the emergency landing gear selector valve which in turn allows the accumulator to discharge into the emergency gear down lines. Emergency pressure is directed through the shuttle valves to the nose gear door actuator and the nose gear actuator. The actuators are retracted to open the doors and extend the nose gear to the down-and-locked position. A leaf spring assembly attached to the lower drag link aids nose gear extension and, if the accumulator pressure fails, this spring is capable of forcing the nose gear to the down-and-locked position.

Simultaneous with nose gear operation, accumulator pressure is directed through the shuttle valves on each main gear door actuator to extend the actuator and open the doors. When the doors open, the uplock mechanism is released and the main gear extends to the down-and-locked position by a combination of gravity and airloads.

During normal operation of the hydraulic system, the accumulator precharge shutoff valve is closed, trapping nitrogen in the accumulator. The emergency pressure dump valve is positioned to connect the accumulator fluid side to the closed emergency landing gear selector valve.

The landing gear control handle is placed in the emergency position by placing the handle in the normal wheels down position, pushing in, turning clockwise, and pulling out. The control handle is connected by cable to the emergency and the normal landing gear selector valves.

Emergency accumulator pressure also actuates the emergency bypass valve, which isolates the normal landing gear return circuit from the emergency return circuit. Emergency return fluid is directed overboard.

Whenever the emergency system has been utilized, the system is returned to normal system configuration by resetting the control handle and leaving the handle in wheels down position. The landing gear emergency selector valve is reset by depressing its leaf springs and moving the valve arm to the closed position. Hydraulic pressure is applied to the system and the landing gear cycled at least two times while checking for normal operation.

MAINTENANCE

Maintenance procedures associated with landing gear systems include periodic inspection, cleaning, lubrication, fabrication of rigid and flexible plumbing, installation of cure-data items, such as O-rings, performing operational checks, troubleshooting, adjustment of linkages, removal and replacement of parts, and occasional damage evaluation. The primary responsibilities of senior AMH personnel in landing gear maintenance are the supervision of drop checks, the evaluation of landing gear damage, and the training of subordinates in the procedures discussed in this manual and the Rate Training Manual for AMH 3 & 2.

Drop Checking Procedures

All landing gear maintenance procedures which involve the removal and replacement of components, breaking of hydraulic lines or fittings, and any adjustments to gear or door linkages generate mandatory requirements for drop checks. Conditional Maintenance Requirements Cards call for a drop check whenever the aircraft experiences a "hard landing." In addition, regular drop checks are required as part of the aircraft periodic inspection, even if there has been no reported discrepancy.

All drop check operations should be in accordance with the applicable Maintenance Instructions Manual and should be thorough enough to ensure that the system is free of leaks and the operational integrity of the system has been restored following maintenance. Operational checking covers three distinct area—the operation of the landing gear and doors, the operation of the landing gear position indicating and warning system, and the operation of the landing gear emergency system.

Since the operation of the T-39D landing gear is featured in this chapter, the same aircraft is used to exemplify a drop check procedure. The first step is to place the aircraft on jacks. Reference should be made to the applicable Maintenance Instructions Manual for specific jacking procedures. A jacking procedure is provided later in this section.

Further preparation includes connection of a hydraulic test stand and external electrical power, removal of landing gear maintenance safety locks, and then placement of the landing gear control handle in the UP position.

As the operational procedure begins, check to ensure that the landing gear doors do not close in the path of the retracting main struts. This condition will be obvious (with hydraulic and electrical power on the aircraft) if the landing gear doors do not remain in the full open position when the landing gear control handle is placed in the UP position. Placing the landing gear control handle momentarily to the

UP and DOWN positions several times will correct this condition by removing air from the wheel door cylinders.

Regulate the hydraulic test stand to operate at a flow of 4 gpm, and slowly increase hydraulic pressure; the landing gear downlock pins should start to retract and should be fully retracted when the pressure reaches 1,800 psi, and then all gear assemblies should start to retract.

When the nose gear nears the up position, be sure the fairing doors are cammed to the closed position, and then check all gear doors to be sure they are closed and locked when the position indicator indicates the up-and-locked condition. Move landing gear handle down and check that wheel fairing doors open and gear assemblies extend. Visually check that all gear assemblies are down and locked. With the test stand regulated to 3 gpm at 3,000 psi, the gear should make a complete cycle (up and down) in 12 to 14 seconds. The maximum pressure required to retract and lock the gear is 1,800 psi at 4 gpm.

When checking the emergency extension of the gear, first retract the gear normally, and then pull and hold the emergency extension handle full aft. Visually check that all gear assemblies are down and locked by observing the landing gear position indicator in the cockpit, and then release the emergency extension handle. With no hydraulic or electrical power on the aircraft, attach a push-pull scale to the emergency extension handle. Pull straight aft. The wheel doors should open and the gear extend. The force applied to the emergency extension handle should not exceed 40 pounds. It may be necessary to manually push the gear assemblies to the down-and-locked position. The force required to push the main gear to the locked position should not exceed 20 pounds applied to the axle hub. The force required to push the nose gear to the locked position should not exceed 10 pounds applied at the centerline of the axle hub. Make at least one complete normal cycle of the landing gear, and then remove external power and the jacks.

JACKING.–At least three receptacles are provided on aircraft for jacking purposes; a fourth receptacle on some aircraft is used to stabilize the aircraft while it is being jacked at the other three points or after it is jacked. The two main receptacles are on the wings, with a smaller on the fuselage near the nose or tail, depending upon the landing gear design. Aircraft with tricycle-type gear have a nose jacking point. The stabilizing jack point is at the tail on this type.

Most aircraft have jack pads that are inserted into the receptacles prior to jacking. The correct jack pad should be used in all cases. The function of the jack pad is to ensure that the aircraft load is properly distributed at the jack point and to provide a convex bearing surface to mate with the concave jack stem or ram.

WARNING: Always refer to the General Information and Servicing volume of the appropriate Maintenance Instructions Manual for the model aircraft being jacked for information pertaining to the proper use of jack pads and jacking procedures. Some jack pads appear similar to those provided for other model aircraft. No substitute should be used unless expressly authorized in the MIM. Some aircraft main jack pads are not interchangeable between the right and left side.

CAUTION: Prior to jacking and before moving the aircraft to the jacking location, ascertain if the aircraft configuration will permit jacking. There may be buddy stores, wing tanks, bombs, rockets, fuel, etc., which have to be removed if serious structural damage is to be avoided during jacking. If any other work is in progress on the aircraft, ascertain if any critical panels have been removed. Some aircraft have stress panels or plates, the absence of which can result in massive structural failure of the airframe while jacking. Likewise, some stress panels must not be removed while the aircraft is on jacks.

Whenever practical, jack the aircraft in a hangar to reduce handling precautions caused by wind. If the aircraft must be jacked outside, head it upwind or downwind, NEVER crosswind.

When the aircraft is properly spotted in the jacking area, install the two main jack pads and the fuselage pad. Position the jacks on the deck below the jack pads with the hydraulic stems in the fully retracted position. Ascertain from the Maintenance Instructions Manual the distance the aircraft needs to be jacked for the wheels to clear the deck by 2 inches. To this distance, add the distance from the jack to the pad. Compare this sum with the rated maximum hydraulic extension of the jack. If the latter dimension is less than that obviously required to perform the jacking operation, extend the threaded extension of the jack stem just enough to give the required height (approximately 1 inch more than the difference between what is required and what is available, in this case).

CAUTION: Avoid overextension of the threaded stem. While its compression strength is equal to the compression strength of the jack as a whole, its thin cross-sectional area makes it particularly susceptible to bending and breaking under side loads, especially when near its full extension.

NOTE: Jacks of specific rated capacity and height are required for every jacking operation. While any two jacks may be similar in construction and outward appearance, the capacity of one may be far greater than the other. As with jack pads, the selection of jacks to be used in a given jacking situation should be carefully checked, then rechecked. Section I of the appropriate Maintenance Instructions Manual is the best source of reliable information.

Raise and position the jacks until the jack pad balls are centered in the ram detents. Ascertain that each jack is solidly seated on the supporting surface, then lock them in place. Recheck the pad balls on the ram detents for center.

The minimum number of persons required for a safe jacking operation is four, one at each of the mains, one at the nose or tail, as appropriate, and one in front to supervise the overall operation.

All jacks should be operated simultaneously, raising the aircraft evenly at all points. The ram safety nuts or collars should be turned down progressively so that if a sudden loss of jack fluid occurs, the aircraft will not drop to the deck. To avoid overloading the jack points, the aircraft must be jacked in an attitude as near level as possible. The supervisor should carefully note the attitude of the aircraft during jacking and relay corrective information to the jack operators as required. In addition to observing the actual jacking operation, the supervisor should keep a close watch on the aircraft overhead clearance. Many fin assemblies have been jacked into overhead structures and damaged during otherwise safe and well-supervised jacking procedures.

Whenever jacking is to be accomplished aboard ship, the jacking operation should not be commenced until permission is clearly authorized by maintenance/production control. Authorization is dependent on the sea state (roughness), anticipated aircraft respotting requirements, the length of time required to complete the drop check, carrier course changes, and any other factors that may be hazardous to the jacking operation.

If the aircraft is jacked outdoors or aboard ship, tiedown equipment should be installed for safety purposes. The tiedowns are installed loosely as soon as the jacks have been positioned. As the aircraft is jacked, the tiedowns will naturally tend to tighten and should be loosened just enough to permit jacking to continue. This cycle should be repeated until the desired height is obtained, at which time the lock collars are screwed down on the jack rams and all tiedowns are tightened.

NOTE: During jacking, there should be no external power connections to the aircraft, and all personnel not concerned with the jacking operation should remain clear.

When removing the aircraft from the jacks, ensure that all obstructions, including stabilizing jack, are clear of the aircraft. The same number of people are required as for jacking. The jacks should be pumped up slightly to release the safety lock collars. The collars should be turned upward on the ram screw threads at about the same rate as the rams are descending. The level attitude of the aircraft should be maintained at all times. Removal of the jack pads from the jack receptacles should be accomplished as soon as the jack is moved clear. The weight of the pad is generally enough to cause the pad to fall out of its receptacle or, if not removed immediately, the possibility of overlooking their removal exists. In either case, a safety hazard is caused. More than one case of an aircraft flying with the jack pad in its receptacle has been recorded and points to the fact that human error can go undetected. While errors of this sort should have been noticed by the supervisor, quality assurance inspector, the plane captain, and the pilot who ultimately flew the aircraft, the maintenance man should not rely on others to see a job through to a safe completion.

Troubleshooting

Troubleshooting of the landing gear system, like all hydraulic systems, requires that the AMH understand the theory of operation of the particular system and the function and sequence of operation for each component.

Troubleshooting steps provided in the Maintenance Instructions Manuals are normally aligned with the sequence of events or steps in the operational checkout and provide an efficient means of isolating the malfunction. Most MIMs require that each step in the operational checkout be performed in sequence. If trouble occurs during the procedure, it must be corrected before proceeding with the next step. These troubleshooting aids provide a logical cause for many anticipated landing gear malfunctions including procedures for isolating and remedying the problem. Reference to the system schematic for the particular system and accompanying maintenance instructions, in addition to sound reasoning, should result in pinpointing the cause for a malfunction in an efficient manner.

Some landing gear malfunctions are related to improper maintenance practices, lack of proper lubrication being the most predominant. A review of past discrepancies and previous corrective actions may also aid in analyzing malfunctions.

Occasionally, discrepancies that are reported as a result of flight are difficult or even impossible to duplicate on the deck. However, too many discrepancies signed off with "Could not duplicate—System checks 4.0" or similar corrective actions show up as repeat malfunctions or as the cause of accidents. Every effort should be made to locate a sound logical cause for a reported malfunction by thoroughly checking the system, each component, linkages, clearance, and associated indicating systems. All phases of the operational checkout must be verified by a quality assurance inspector.

Detecting internal leakage of components may require the use of special equipment such as the ultrasonic leak detection translator, discussed in chapter 6, or simple isolation of components by disconnecting lines, applying pressure, and measuring for allowable leakage limits.

If troubleshooting time is considered significant, a separate single-copy Maintenance Action Form showing a common job control number and action taken code "Y" should be utilized to provide input data that accounts for the troubleshooting time and actual repair time separately.

Alignment/Adjustment

Improper rigging or adjustment of landing gear linkages results in a significant number of unsafe or hung landing gear discrepancies. Most landing gear, when in an overcenter and locked position (up or down), requires very little interference or binding to prevent their initial movement.

Alignment of newly installed landing gear assemblies or individual components should be in strict accordance with the procedures outlined in the applicable Maintenance Instructions Manual. Complete assemblies are aligned in a specified sequence with designated steps throughout the sequence requiring quality assurance verification, prior to proceeding to the next step. Landing gear doors may have to be deactivated or disconnected to check for proper uplock actuation and gear up clearances. Complete alignment includes down-and-locked adjustment, up-and-locked adjustment, and proper door operation. Verification of the emergency landing gear system operation is normally required in verifying the landing gear system. Some Maintenance Instructions Manuals cover the emergency system as a separate procedure, but a complete operational checkout should include the emergency backup system.

CAUTION: Ensure that all personnel involved in landing gear maintenance are clear of the landing gear and doors and that signals between the man in the cockpit and the crewleader are clearly understood prior to raising or lowering the landing gear.

The *AMH 3 & 2* Rate Training Manual provides coverage on the adjustment and alignment of some common landing gear mechanisms.

Landing Gear Alignment Checks/Damage Evaluation

Misalignment of the landing gear may be an indication of structural damage not otherwise apparent. Misaligned landing gear can cause excessive tire, brake, and bearing wear, all of which can contribute to eventual failures. For these reasons an alignment check should be performed when an aircraft has encountered excessive Gs in flight, when a hard landing has been experience, or when the aircraft has been subjected to extensive damage. Taking accurate measurements should reveal any distortions and irregularities that may contribute to unfavorable landing gear performance and subsequent failure.

Before the alignment check is performed, the aircraft in most cases must be defueled, then placed in the hanger to prevent air currents from interfering with the accuracy of the alignment readings. The aircraft should be leveled laterally and longitudinally. The leveling may be accomplished by using the spirit level method, a plumb bob method, a clinometer or whatever method is recommended in the applicable Structural Repair Manual. All landing gear should be in the fully extended position and the engine, seats, and canopy are normally installed.

NOTE: The aircraft should be prepared for an alignment check in accordance with the instructions contained in the applicable Structural Repair Manual.

DAMAGE EVALUATION.–In determining the extent of damage caused by hard landing or landing gear malfunction, the senior AMH must thoroughly inspect the damaged area, keeping in mind that primary-damage areas can transmit destructive loads to structural members far removed from the immediate area and could result in secondary damage.

Certain areas of the nose and main landing gear are considered critical and must be carefully examined. Alignment checking and use of one or more of the nondestructive metal inspection methods should be accomplished whenever there is doubt as to the amount of damage incurred in any structure.

There are various types of landing gear failures that could occur, and the damage sustained by the airframe structure and landing gear mechanisms will vary with each type of failure. Structures that are extensively damaged are best repaired by replacement of parts and assemblies, whenever possible. Should a question arise regarding repair or replacement, careful consideration must be given to factors, such as weight, strength replacement, equipment availability, and time element involved.

The Structural Repair Manuals generally provide for specific evaluation criteria and repair procedures for each type of gear failure, such as: nose gear failure, main gear failure, all gear up failure, nose and one main gear up failure, one main gear up failure, and barricade engagement damage with gear up or down.

The preliminary external and the detailed inspection for damage include careful examination of skin for buckling, tears, cracks, wrinkles, and misalignment, checking for the fit of doors, panels, and covers, cocked or sheared fasteners, bolt hole elongation, paint appearance, and any other apparent indications. Pay particular attention to areas where major components are joined or where heavy weight or stress is concentrated. The inspection and evaluation by necessity continues throughout the disassembly and repair process. When new parts being installed do not fit properly, investigate the cause. It may be because of damage which has been previously overlooked.

Repair or replacement of movable members should include operationally checking for freedom of movement, proper clearance, and alignment following the procedures provided in the applicable Structural Repair Manual and Maintenance Instructions Manual.

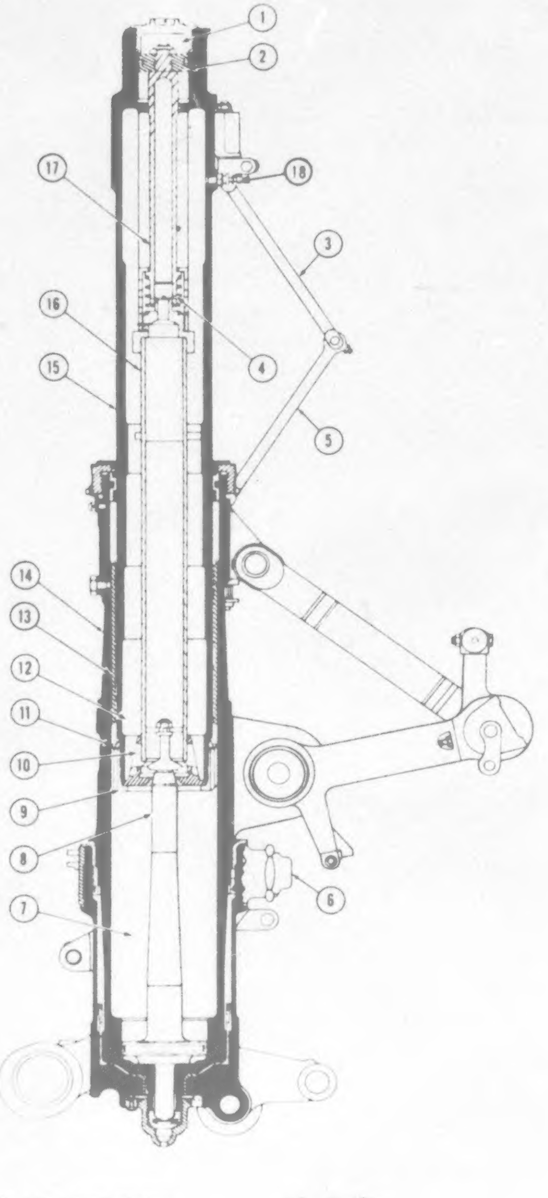
RECOIL STRUTS

Most recoil struts on aircraft landing gear are of the hydropneumatic type, using hydraulic fluid and nitrogen to absorb landing impact and taxiing loads. They are considered structural members which transmit loads from the wheel to the airframe. They provide a resilient medium for absorbing and damping out the oscillations resulting from taxiing. They also absorb and largely dissipate the kinetic energy of the landing aircraft without building up excessive resistance loads and without permitting a high rebound.

OPERATION

Loads developed by the aircraft during landing and taxiing are absorbed by the metering of hydraulic fluid and the compressed nitrogen in the strut. The nitrogen under pressure also serves to extend the strut so that it is ready to receive the next compression load. The impact energy of landing is transmitted through the walls of the strut in the form of heat.

During an approach for a landing, the recoil strut is in the fully extended position, as illustrated in figure 8-4. As the landing shock load is applied to the strut, the cylinder moves upward, hydraulic fluid is gradually restricted from flowing through the orifice, into the piston chamber, by the taper of the metering pin that closes the orifice as the pin travels upward into the piston. This restriction absorbs most of the landing impact and is supplemented by the action of the pressurized nitrogen, which tends to extend the piston by forcing hydraulic fluid out of the piston chamber and back into the cylinder chamber. The pressure of the nitrogen on the hydraulic fluid tends to give the aircraft a bouncing motion that is counteracted by the recoil valve in the piston assembly. As the cylinder initially telescopes upward, hydraulic fluid flows through 16 holes in the piston head and lifts the recoil valve from its seat on the piston head. Fluid fills the space formed between the piston follower and the recoil valve. When the strut extends, the follower is carried downward with the cylinder assembly and forces hydraulic fluid in the recoil chamber, around the recoil valve, and through the 16 holes in the piston head. As the fluid moves downward, the recoil valve seats on the piston head and two small holes in the recoil valve permit fluid flow back into the cylinder chamber. This restricted flow of the fluid slows the downward movement of the cylinder and inhibits bouncing.



1. Upper chamber.
2. Head.
3. Upper steering arm.
4. Orifice holes.
5. Lower steering arm.
6. Snaplock assembly.
7. Cylinder chamber.
8. Metering pin.
9. Piston head.
10. Orifice.
11. Recoil valve.
12. Piston chamber.
13. Follower.
14. Cylinder assembly.
15. Piston assembly.
16. Lower tube.
17. Upper tube.
18. Air valve.

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Figure 8-4.–Nose strut and lock assembly. (A-6A)

DESIGN FEATURES

While most landing gear recoil struts are similar in external appearance, internally they may possess a variety of design differences. On some aircraft the outer cylinder barrel is attached to the aircraft structure, and the piston axle assembly telescopes into the outer barrel. On other aircraft this arrangement is reversed with the outer cylinder barrel being attached to the axle. In either arrangement the principles of operation remain the same.

The Rate Training Manual for AMH 3 & 2 illustrates and discusses the metering pin and metering tube-type recoil strut design as well as the sequence of events occurring internally as the strut extends and compresses. In this section, coverage will be devoted to modifications to these basic designs.

Strut Lock (Nose Catapult Extension)

Several navy aircraft utilize pneumatic or hydraulic pressure to render the nose strut almost rigid for maintaining the proper angle of attack for catapult takeoffs. Figure 8-4 illustrates the nose strut lock feature of the A-6A aircraft. The strut lock portion is actuated by combined hydraulic system pressure when the catapult grip handle is positioned for catapulting. A pressure warning switch provides an indication of hard or soft strut condition to the pilot's annunciator panel. A NOSE STRUT or STRUT LOCK light on indicates an unsafe or soft strut condition.

With the throttles forward and the catapult grip rotated to the catapult position, the selector valve is opened to direct pressure through the strut lock swivel into the upper chamber of the strut forcing the head and upper tube downward on the piston. Four orifice holes in the upper tube are sealed as the tube moves downward and bottoms on the lower tube. Further movement causes the lower tube to move downward and seal the three radial openings in the orifice. This causes the interior of the lockout tube assembly to become a sealed chamber that prevents flow of hydraulic fluid from the cylinder chamber into the piston chamber, thus the strut becomes almost rigid. It does not become completely rigid because a little fluid passes through the 16 holes in the piston head and because, when the strut assembly is initally filled with hydraulic fluid, nitrogen is trapped above the orifice holes in the upper tube. This nitrogen, which can be compressed, and the hydraulic fluid that passes through the piston head provide dampening that prevents the strut assembly from becoming completely rigid. When the aircraft has been launched, the catapult grip handle is released and the selector valve is deenergized to port hydraulic fluid from the upper chamber to system return. The lockout tube assembly is released and the strut assembly regains its telescoping characteristics.

Soft Strut Feature (P-3C)

The standard and modified (soft) main landing gear struts of the P-3 aircraft are illustrated in figure 8-5. Although there is a wide variety in the design of recoil struts on heavy aircraft, conventional designs share the same basic operating principles possessed by the standard strut in figure 8-5.

While airborne with gear down, gravity and the force of the nitrogen precharge pressure hold the piston axle assembly at the fully extended position. Within a fraction of a second following runway contact a heavy reactive force, resulting from the tires and wheel assemblies being accelerated and the piston assembly being violently accelerated into the cylinder, is transmitted to the airframe. These two forces are directed diagonally aft and upward, tending to bend the piston at the point where it bears on the aft wall of the cylinder entrance. The relatively high friction caused by the aft force increases the vertical shock considerably throughout the wheel spin up interval.

As the aircraft weight settles, the shock rate is controlled by hydraulic snubbing as fluid is metered through the orifice plate against a rapidly rising nitrogen pressure. During rollout and taxiing the full weight of the aircraft is supported by the highly compressed nitrogen precharge, with comparatively minor piston travel controlled by hydraulic snubbing. As with most struts, the most severe jolt occurs during the first few inches of piston travel.

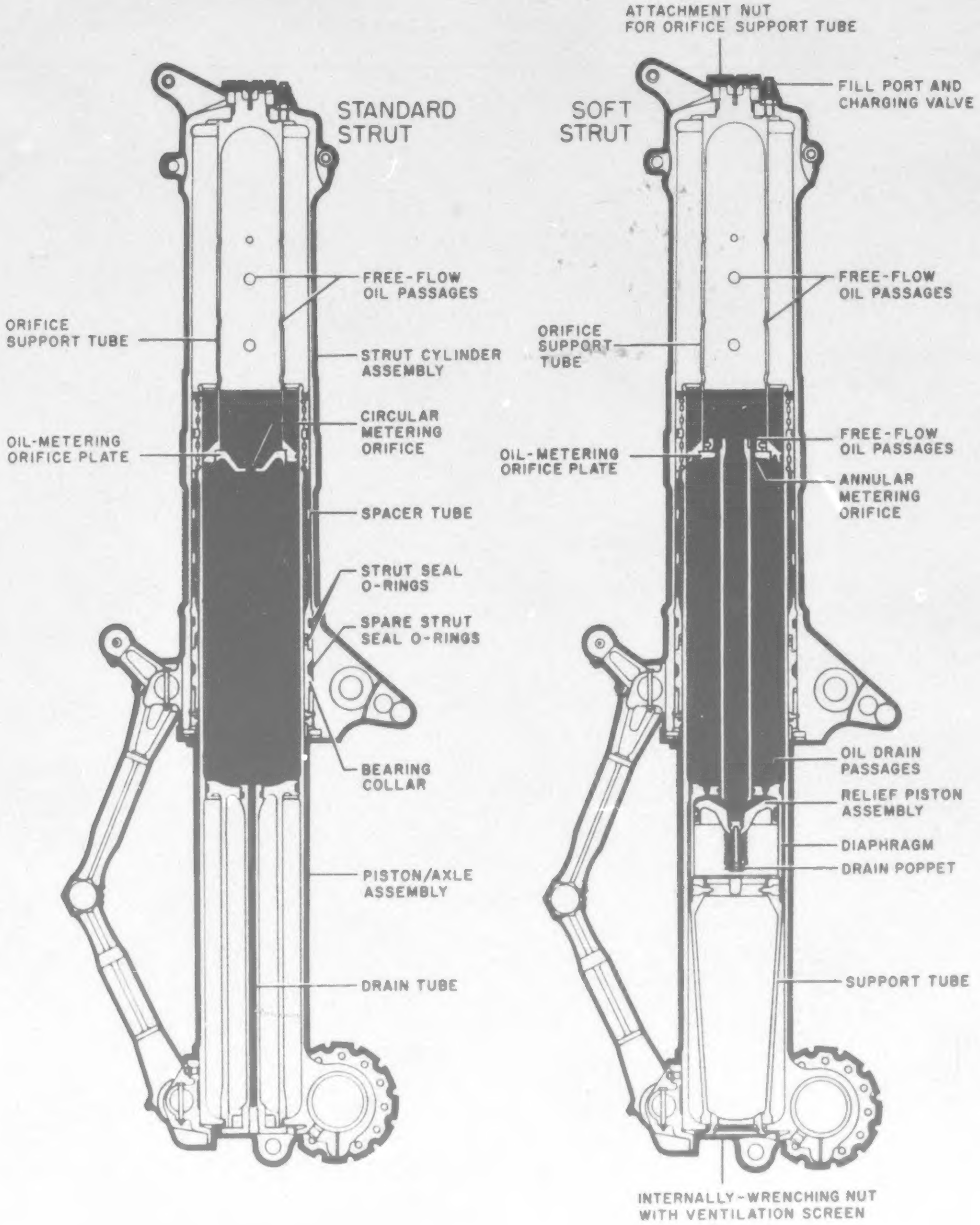
ATTACHMENT NUT FOR ORIFICE SUPPORT TUBE
FILL PORT AND CHARGING VALVE
STANDARD STRUT
SOFT STRUT
FREE-FLOW OIL PASSAGES
ORIFICE SUPPORT TUBE
STRUT CYLINDER ASSEMBLY
ORIFICE SUPPORT TUBE
FREE-FLOW OIL PASSAGES
CIRCULAR METERING ORIFICE
OIL-METERING ORIFICE PLATE
OIL-METERING ORIFICE PLATE
FREE-FLOW OIL PASSAGES
ANNULAR METERING ORIFICE
SPACER TUBE
STRUT SEAL O-RINGS
SPARE STRUT SEAL O-RINGS
BEARING COLLAR
OIL DRAIN PASSAGES
RELIEF PISTON ASSEMBLY
DIAPHRAGM
DRAIN POPPET
PISTON/AXLE ASSEMBLY
DRAIN TUBE
SUPPORT TUBE
INTERNALLY-WRENCHING NUT WITH VENTILATION SCREEN

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Figure 8-5.–Main gear struts (P-3).

The modification of the standard strut shown in figure 8-5 alleviates this jolt. The lower part of the soft gear modification assembly comprises a relief piston, which utilizes the oleo as a traveling cylinder that runs full stroke during the initial 3.5 inches of travel of the oleo piston. While airborne, the effective area of the strut pressure chamber, which was maximum and constant on the conventional strut, is divided into two major areas–an inner and outer area. The pressure of the nitrogen precharge acts only on the outer area or about 20 percent of the total to hold the oleo at full extension. The larger inner area is completely ineffective except for a small central area that holds the relief piston in position, bottomed on the orifice plate. At touchdown, the force required to move the oleo from rest (break away force) is equal to the precharge pressure acting on the small outer area. Thus, the tires are able to deflect the oleo piston upward quite easily against the force of precharge that is only 20 percent as effective as the standard strut.

During the first 3.5 inches of travel of the oleo piston, hydraulic fluid below the orifice plate is forced through the orifice into the upper chamber, oil from the upper chamber flows through the hollow relief piston rod to fill the expanding cavity below the diaphragm. In this interval, the amount of hydrulic fluid forced through the metering orifice is about the same on both sturts. However, the precharge pressure in the soft strut increases very little and the dampening effect of hydraulic snubbing is reduced accordingly. This results in less tire friction on the runway during the initial 3.5 inches of oleo travel. Wheel acceleration is more gradual and the reactive force generating friction between the oleo piston and the cylinder is substantially reduced. When the lower relief piston land bottoms on the oleo piston, the upper land is lifting off the orifice plate. At this point hydraulic snubbing and the accompanying precharge pressure buildup rate becomes approximately the same as that of the standard strut.

Overall, the modification of the standard strut provides for an increase in the weight of the aircraft with a substantial decrease in gravitational loads imposed on the aircraft structure during landings, while at the same time providing better protection to the intricate electronic equipment being placed in the later model patrol aircraft.

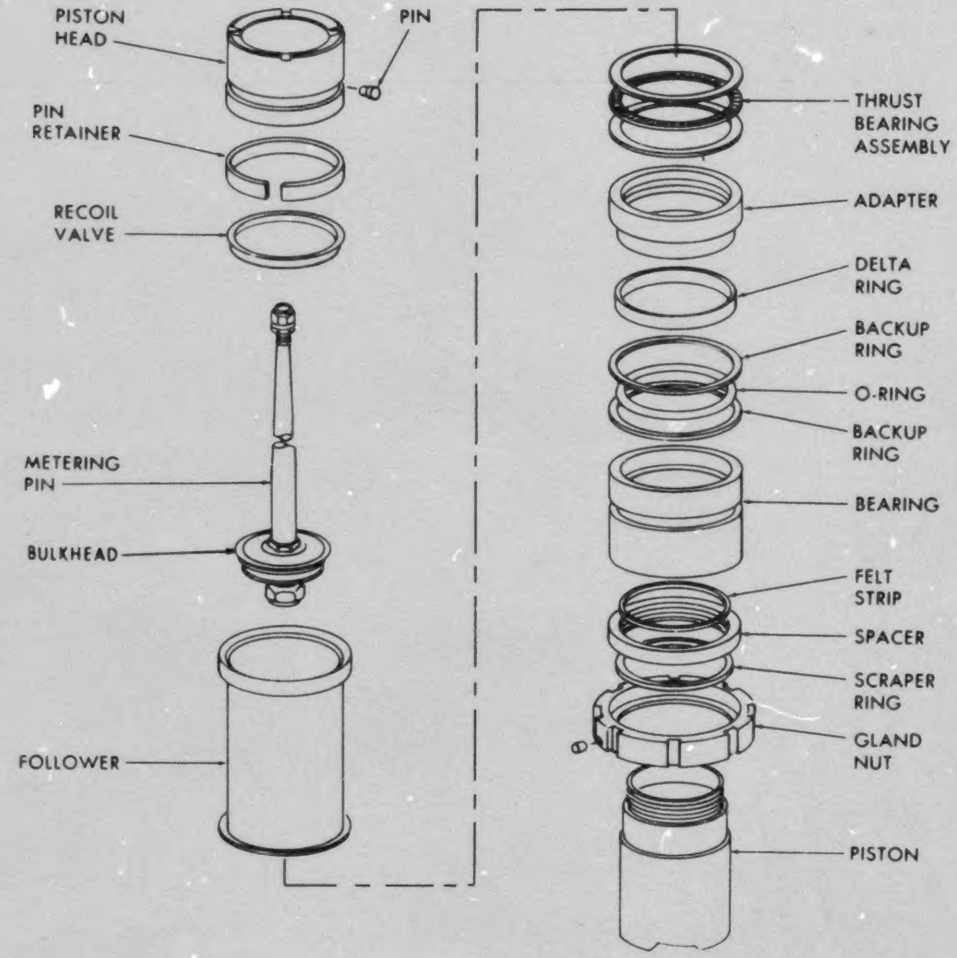
MAINTENANCE

According to current maintenance directives, maintenance of recoil struts, including minor repair and miscellaneous parts replacement, shall be confined to that work which can be performed with only partial disassembly of the equipment. Instructions for major or complete overhaul are covered in Overhaul Instructions Manuals for recoil struts, and such work is to be performed by specialized shops engaged in such work.

Lower Strut/Gland Seal Replacement

On most aircraft the piston O-rings and delta rings can be replaced at the organizational level of maintenance with the strut installed on the aircraft. Procedures for replacing the seals in a main gear recoil strut at the organizational level of maintenance consist of jacking the aircraft in accordance with the applicable Maintenance Instructions Manual. Remove the wheel and brake assemblies so that handling of the lower strut is easier. Remove the cap from the strut filler valve and release the nitrogen pressure from the strut by opening the valve swivel nut counterclockwise. Remove the necessary wire bundles, hydraulic lines, etc. that form a connection between the upper cylinder and lower piston of the strut. Remove the up and down lines from the gear actuating cylinder and connect a hand pump or check and fill stand lines so that the strut may be retracted to an angle which will allow the piston to be withdrawn from the cylinder. Cap any loose lines or fittings to prevent contamination. On some aircraft it will be necessary to use a spring compressor or some other means to release tension on the gear down lock mechanism so that the gear can be partially retracted.

With the strut cylinder secured in the partially retracted position and all pressure released from the strut, the upper and lower torque arms can be disconnected. Cut the lock wire and remove the lock screws from the gland


PISTON HEAD
PIN
PIN RETAINER
RECOIL VALVE
METERING PIN
BULKHEAD
FOLLOWER
THRUST BEARING ASSEMBLY
ADAPTER
DELTA RING
BACKUP RING
O-RING
BACKUP RING
BEARING
FELT STRIP
SPACER
SCRAPER RING
GLAND NUT
PISTON

216.128

Figure 8-6.—Main gear recoil strut piston (A-6A).

nut. Figure 8-6 illustrates the main gear recoil strut piston for the A-6A aircraft and should be referred to while reading the following seal replacement material.

With the piston supported, the collar or gland nut is unscrewed and the piston withdrawn from the cylinder. Pour the hydraulic fluid into a suitable container and place the piston/axle assembly in a clean work area. Inspect the hydraulic fluid for evidence of rubber or metal particles that might indicate wear conditions within the strut.

Remove the pin retainer and three pins from the piston head; then remove the piston head and the recoil valve. On some aircraft the retaining pins are pressfit while on others they are screwed in. Remove the metering pin assembly, follower, thrust bearing assembly, adapter, delta ring, and other removable parts in the order in which they are installed on the piston assembly as shown in figure 8-6.

The cylinder walls, piston head, adapter, follower, and bearings should be inspected for excessive wear and sharp edges. Minor nicks, scratches, or sharp edges can be polished out with crocus cloth (steel parts) or aluminum oxide abrasive cloth (aluminum parts).

Coat all seals and backup rings with hydraulic fluid and install in the reverse order of the disassembly sequence. Ensure that the adapter, follower, and recoil valve are facing in the right direction on the piston assembly. Once the piston assembly is reassembled, quality assurance should check for proper reassembly prior to inserting it into the cylinder.

The inner surface of the cylinder and the outer surface of the piston are coated with hydraulic fluid, and the piston is immediately installed in the cylinder. The gland nut is tightened and the lock screws installed and safety wired. The torque arms are reconnected and the strut lowered to its normal extended position. All linkage, hydraulic lines, wire bundles, and the brake and wheel assemblies are installed in the reverse order of their removal. The strut is serviced in accordance with the applicable Maintenance Instructions Manual or Maintenance Requirement Card. Servicing is covered in the *AMH 3 & 2* Rate Training Manual.

Proper servicing cannot be overstressed. Not all struts are serviced in a standard manner. Consult the appropriate MIM to prevent improper servicing and subsequent landing gear or structural failure. All linkage on the lower strut that was disturbed must be lubricated, the brakes bled, and the brakes and the landing gear systems operationally tested.

Strut Removal and Replacement

To remove a strut assembly the aircraft should first be jacked in accordance with instructions furnished in the applicable Maintenance Instructions Manual. To reduce the weight and allow for easier handling, the wheel (with tire and brake assembly) should be removed.

WARNING: Prior to removing split rim wheels from aircraft, the tire should be completely deflated. To ensure positive removal of all pressure from the tire, the valve core should be removed.

Remove all attached fairings and door connecting rods. Disconnect and cap the hydraulic brake lines and fittings. Disconnect electrical connections at the cannon plugs and remove wiring from clamps as necessary. Retain all removed hardware in a cloth bag.

Disconnect the drag brace by partially pulling the upper torque arm root pin. After disconnecting the drag brace, reinstall the pin and nut to retain the torque arm.

The side brace is generally removed with the strut assembly. It should be disconnected at its upper end by removing the nut and pin. After the side brace is disconnected, reinstall the pin.

If equipped with a shrink rod, the shrink rod is disconnected from the strut–not from the aircraft. This is accomplished by removing the rod fitting bolt at the bottom of the rod. When the shrink rod is disconnected, the nut and bolt should be reinstalled in the fitting for safekeeping.

Support the recoil strut and partially pull the crossbolt at the top of the strut to disengage it from the support structure. Lower the strut and reinstall the bolt and nut.

Installation essentially reverses the removal procedures. With the aircraft still on jacks, carefully move the top of the recoil strut into place to engage the support structure fitting. Install the crossbolt, washer, nut, and cotter pin. Connect the shrink rod to the shrink rod fitting. Connect the side brace to the support structure fitting. Partially pull the upper torque arm root pin and connect the drag brace. Reinstall the pin, tongued washer, nut, and cotter pin.

Assemble the brake and wheel to the strut axle, bleed the brake, and service the strut in accordance with the aircraft Maintenance Instructions Manual. Ensure that the air valve is safety wired prior to charging the strut with nitrogen. After the strut has been serviced with hydraulic fluid and nitrogen, tighten the air valve to the specified torque value found in the MIM. Replace all removed fairings, doors, hydraulic lines, and electrical connections. Lubricate all reinstalled linkages and check the landing gear for proper operation.

Intermediate Maintenance
Repair/Seal Replacement

Repair of recoil struts at the intermediate level of maintenance is restricted to seal replacement and replacement of parts listed in the Spares and Repair Parts Data listing within the Intermediate Maintenance Section of the aircraft Maintenance Instructions Manual or the appropriate 03 Manual. The following paragraphs provide information on the disassembly, cleaning, inspection, parts replacement, and reassembly of a strut at the intermediate level.

DISASSEMBLY.–Disassemble the strut assembly in the order of the key index numbers assigned to the exploded view illustration provided in the appropriate 03 series Accessories Manual or the Intermediate Maintenance Section of the applicable Maintenance Instructions Manual.

Prior to beginning disassembly, ascertain that all air has been exhausted from the strut. Do not loosen or attempt to back off the 3/4-inch hex valve stem nut on the air valve, or disassemble the inner and outer cylinder until all the air has been released from the strut. Disassembly of the strut prior to releasing all air pressure could lead to serious personnel injury or loss of life. Remove the complete air valve assembly by breaking the lockwire and unscrewing the 3/4-inch hex nut. Turn the strut over and drain the hydraulic fluid. Pour the hydraulic fluid through a filter, observing for small particles of rubber or metal that will indicate a wear condition within the strut.

Disconnect the torque arms (scissors). Break the lockwire and unscrew the packing nut at the bottom of the outer cylinder. Carefully withdraw the inner cylinder from the outer cylinder. Pull the metering pin and bulkhead from the inner cylinder with a smooth controlled force. Tag or keep parts together to facilitate reassembly.

CLEANING.–Thoroughly clean all parts of the recoil strut assembly, using Cleaning Solvent P-D-680 (spray or dip) or a similar cleaning solvent. Dry thoroughly with clean, dry, compressed air, paying particular attention to all recesses and internal passages. Use the cleaning solvent in a well-ventilated area. Avoid prolonged inhalation of fumes. Keep solvent away from open flames.

Cleaned parts that normally come in contact with fluid during operation of the strut should be coated with hydraulic fluid Specification MIL-H-5606. Depending on local conditions, it may be desirable to also coat external highly machined surfaces.

Wipe lower bearing clean with a clean, lint-free cloth dampened with MIL-H-5606 hydraulic fluid. Do not touch machined surfaces with the bare hands. Do not use compressed air to dry bearings. Clean the bearings with new cleaning solvent and dry with a lint-free cloth.

INSPECTION.–Perform a thorough visual inspection of the disassembled parts for serviceability. Packing grooves and surrounding areas should be inspected for scratches, burrs, nicks, or other roughness that might cut packings on installation or cause seal failure during strut operation. Inspect machined surfaces for mars, abrasions, gouges, grooves, scores, scratches, and corrosion. If any parts are suspected of having cracks, the part should be inspected utilizing one of the nondestructive methods of testing.

All threaded parts should be checked for distorted or mutilated threads. Inspect plated surfaces for blistering, flaking, wear, or other defects.

Within the limits of practicability, check all holes for concentricity and taper, using internal micrometer, hole gages, plug gages, or similar equipment. Check the angle between the piston and the axle. Check to ensure that the brake flange is perpendicular to the axle. Inspect all ports, bores, and passages for cleanliness. Place bearings next to a sensitive compass to check for residual magnetism.

Bearings should be inspected for obvious damage, brinelling (shallow indentations in the raceway), or corrosion. Rotate bearing races and check for roughness, binding, or looseness. Bearing retainers must be checked for cracks, warpage, and corrosion. Refer to tables furnished in the applicable Accessories Manual or Intermediate Section of the appropriate

Maintenance Instructions Manual for service limits established for critical areas.

REPAIR OR REPLACEMENT.–Repair or replace all parts that show evidence of excessive wear, scoring, or corrosion. Replace parts that show wear beyond the dimensions specified in the inspection standards tables found in most 03 Manuals of MIM.

Each time the strut is disassembled, all preformed and special packings should be replaced, regardless of the fact that they may appear to be serviceable.

Blend out minor scratches, nicks, and burrs from machined surfaces of steel parts with crocus cloth. Use aluminum oxide abrasive cloth to polish aluminum parts. Finish smoothness of the repair area must be equivalent to or smoother than the finish of the surrounding area of the part. Do not attempt to remove normal wear marks from the sliding surface of the piston.

NOTE: Partial removal of plating from the inner cylinder will condemn the part for further service, pending replating of the cylinder. Portable brush-type plating equipment is available in some intermediate maintenance activities for touchup plating of minor areas.

Areas with damaged paint or other protective finishes must be restored to a serviceable condition.

If any bushings require replacement, the mating bushing must also be replaced.

REASSEMBLY.–Reassemble the strut assembly in essentially the reverse order of disassembly. Exercise adequate precautions to ensure that dirt, dust, grit, or other foreign matter does not enter the strut during assembly. Contamination of parts can cause definite failure and cannot be overemphasized.

Observe the torque values specified in the 03 Manual or MIM. Where a specific torque value is not specified for a threaded part, tighten the part in accordance with standard torque values provided in the *Structural Hardware Manual*, NAVAIR 01-1A-8. Some Structural Repair Manuals and Maintenance Instructions Manuals also contain this information. On some parts, such as the strut gland nut, tightening should conform to acceptable shop practices and common sense, unless otherwise specified.

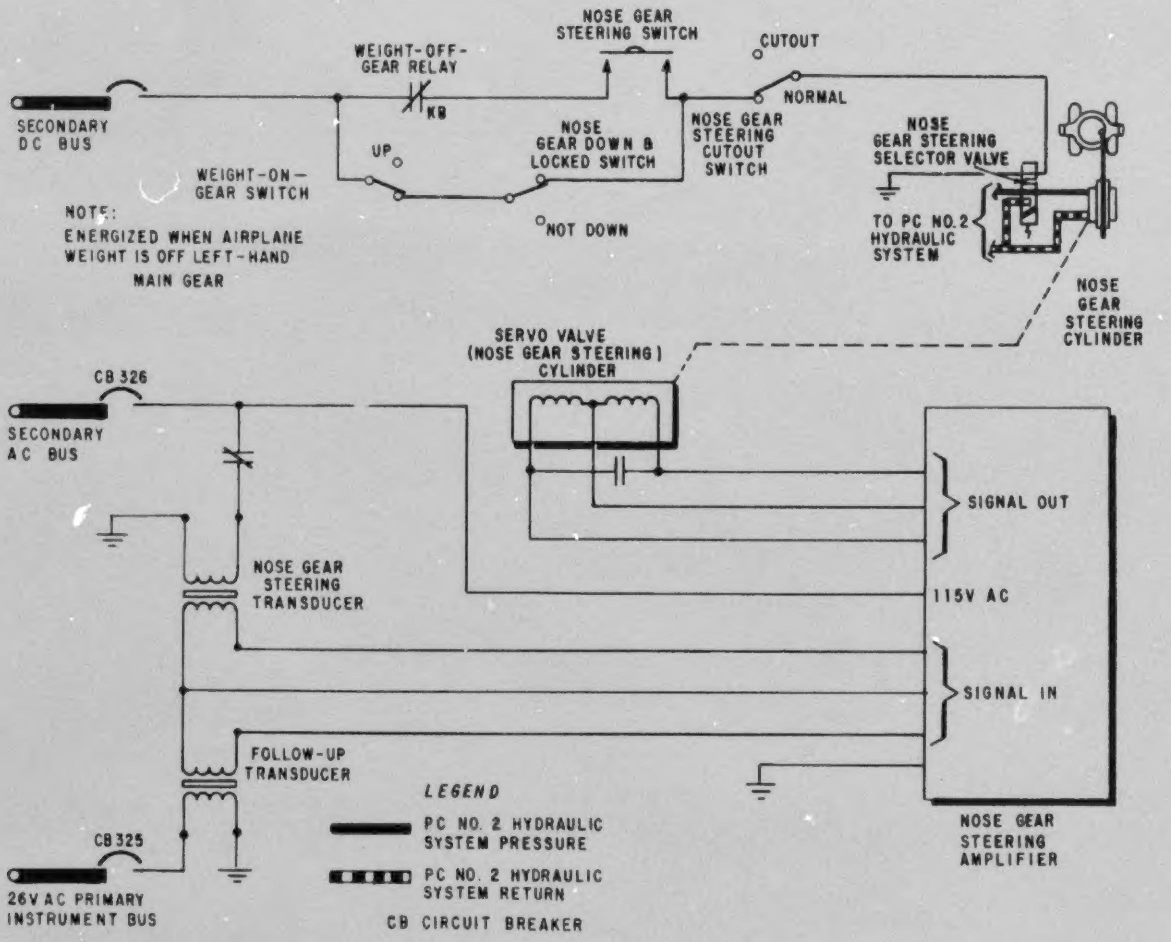
Lightly coat all preformed packings with hydraulic fluid. With all seals and parts properly installed, the piston head is tightened and the retaining pins installed and staked into place. The piston assembly is inserted into the outer cylinder and the gland nut is tightened to a snug fit, backed off two key slots, and locked in place. If the gland nut is too tight, it will result in binding of the thrust bearing. (See fig. 8-6.) Two lock plates, positioned 180° apart on the collar and gland nut, are secured with screws and lockwired to hold the gland nut in place. Use the double twist method of applying the lockwire so that tension of the wire tends to tighten the nut.

BENCH TESTING.–With the strut fully compressed and in the vertical position, fill the strut with hydraulic fluid. Install the air valve on the strut and torque to 100-110 inch-pounds. Place the strut fully extended in a horizontal or vertical position and inflate with dry nitrogen to the normally extended pressure specified in the MIM or 03 Manual. Check that the strut shows no leakage after a 1-hour interval.

If the strut fails the bench test, it is tagged to show the portion of the test that failed, then deflated, flushed with MIL-H-6083 preservative hydraulic fluid, and forwarded to the next higher level of maintenance.

If the strut passes the bench test and is not to be installed on an aircraft immediately, flush with preservative hydraulic fluid prior to sending to supply.

If any parts other than those listed as replaceable at the intermediate level of maintenance are faulty, the strut is tagged and forwarded to the next higher level of maintenance. The number three copy of the Maintenance Action Form is closed out to account for manhours expended in attempting repairs prior to the strut being declared beyond the capability of maintenance (BCM). If an Unsatisfactory Material Condition (UR) form was attached to the strut by the removing


NOSE GEAR STEERING SWITCH
WEIGHT-OFF-GEAR RELAY
CUTOUT
NORMAL
K8
SECONDARY DC BUS
UP
NOSE GEAR DOWN & LOCKED SWITCH
NOSE GEAR STEERING CUTOUT SWITCH
NOSE GEAR STEERING SELECTOR VALVE
WEIGHT-ON-GEAR SWITCH
NOTE:
ENERGIZED WHEN AIRPLANE WEIGHT IS OFF LEFT-HAND MAIN GEAR
NOT DOWN
TO PC NO. 2 HYDRAULIC SYSTEM
NOSE GEAR STEERING CYLINDER
SERVO VALVE (NOSE GEAR STEERING) CYLINDER
CB 326
SECONDARY AC BUS
SIGNAL OUT
NOSE GEAR STEERING TRANSDUCER
115V AC
SIGNAL IN
FOLLOW-UP TRANSDUCER
LEGEND
PC NO. 2 HYDRAULIC SYSTEM PRESSURE
PC NO. 2 HYDRAULIC SYSTEM RETURN
CB CIRCUIT BREAKER
CB325
26V AC PRIMARY INSTRUMENT BUS
NOSE GEAR STEERING AMPLIFIER

216.129

Figure 8-7.—Nose gear steering system diagram (A-7E).

organizational maintenance activity, the UR is completed and submitted in accordance with the instructions provided in OPNAV Instruction 4790.2 (Series).

Any unusual failure or strut malfunction should be reported by the submission of a UR in order that failure trend patterns or isolated instances may be reviewed for possible higher echelon action. The number four copy of the MAF and the hard copy of the UR should be forwarded with the strut to the next higher level of maintenance.

NOSE STEERING SYSTEMS

ELECTRICALLY CONTROLLED NOSE STEERING SYSTEM

The A-7E nose steering system is an electrically controlled, hydraulically actuated system which provides power steering. When not engaged the system provides automatic nose gear shimmy damping.

The nose gear is steered by an electrically controlled, hydraulic powered steering cylinder which is mounted on the nose gear recoil strut.

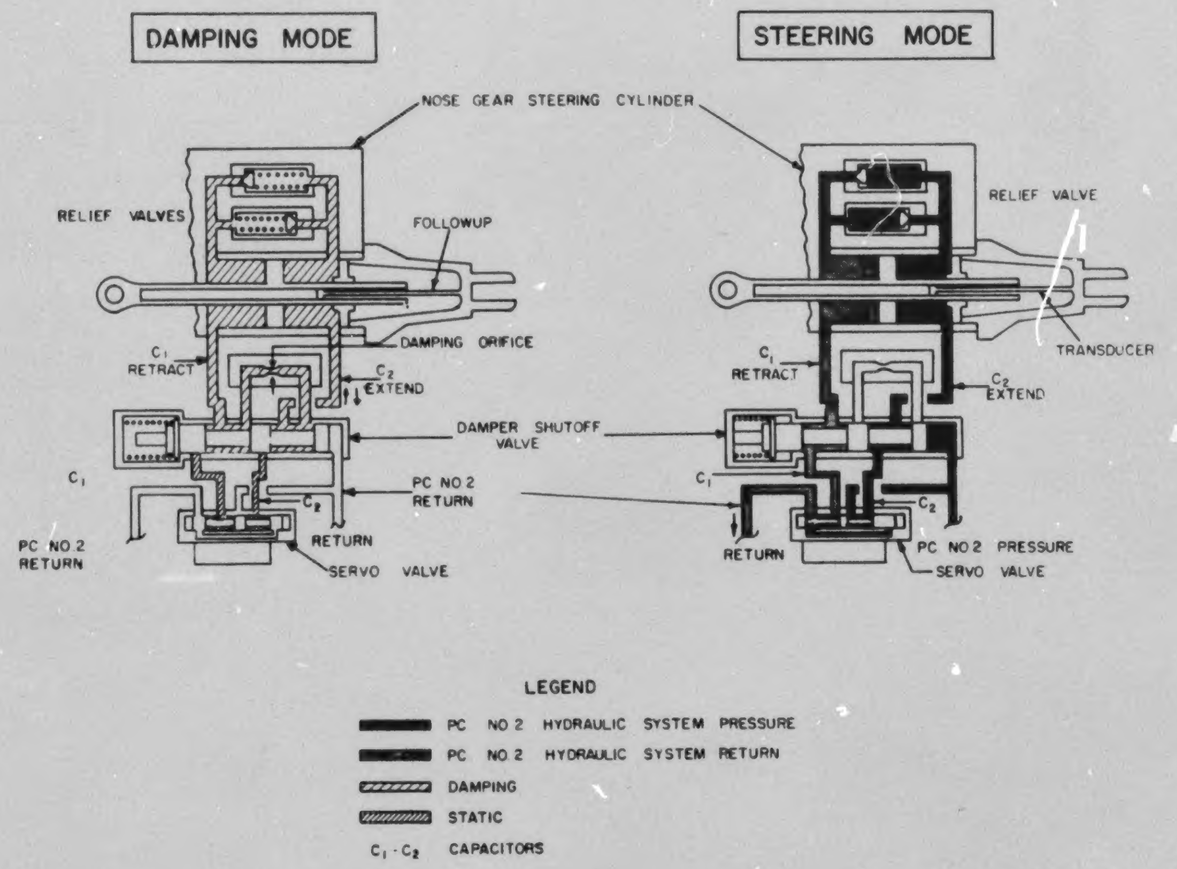

DAMPING MODE
STEERING MODE
NOSE GEAR STEERING CYLINDER
RELIEF VALVES
FOLLOWUP
RELIEF VALVE
TRANSDUCER
DAMPING ORIFICE
C1 RETRACT
C2 EXTEND
C1 RETRACT
C2 EXTEND
DAMPER SHUTOFF VALVE
C1
PC NO 2 RETURN
C2
C1
C2
PC NO 2 RETURN
RETURN
SERVO VALVE
RETURN
PC NO 2 PRESSURE
SERVO VALVE
LEGEND
PC NO 2 HYDRAULIC SYSTEM PRESSURE
PC NO 2 HYDRAULIC SYSTEM RETURN
DAMPING
STATIC
C1 - C2 CAPACITORS

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Figure 8-8.—Nose gear steering cylinder schematic diagram.

The cylinder is connected through mechanical linkage to an eccentrically mounted drive stud on the recoil strut inner cylinder.

Operation

Nose gear steering power is obtained when the switch on the pilot's stick grip is depressed and held. This applies electrical power to the nose gear steering selector valve, which directs hydraulic pressure to the steering cylinder. Aircraft with A-7 Airframe change No. 122 do not require that the switch be held after initial depression. To disengage, press and release switch again. Figure 8-7 is a steering system diagram of the nose gear steering system.

Figure 8-8 is the steering cylinder schematic diagram.

When the appropriate rudder pedal is depressed, steering electrical control signals are supplied to the cylinder servo control valve. The servo control valve ports hydraulic pressure to the cylinder piston which extends or retracts and turns the nose gear the amount demanded by rudder pedal deflection. The secondary dc, secondary ac and 26-volt primary ac instrument buses must be energized before the steering system will operate. Secondary dc power is distributed through closed contacts of the deenergized weight-off gear relay to the open contacts of the nose gear steering switch and the arresting gear up-and-locked switch.

Secondary ac power is distributed through closed contacts of the deenergized weight-off-gear relay to energize the nose gear steering input transducer primary coil. Instrument bus power is applied directly to energize the followup transducer primary coil. When the nose steering switch is depressed and held, dc power is applied through closed contacts of the nose gear steering cutout switch to energize the steering selector valve. The valve cycles to apply hydraulic pressure to the steering cylinder servo valve. The steering system is now engaged and in the null (void) condition (nose gear centered, rudder pedals not deflected).

With arresting gear down, dc power is applied through the not-up side of the arresting gear up-and-locked switch and the down side of the nose gear down-and-locked switch through the nose gear steering cutout switch to energize the nose gear steering selector valve. Under these conditions, the primary coil of the nose gear steering followup transducer is energized. The primary coil of the input transducer is not energized until weight is on the left gear and the nose gear steering switch is energized. If the nose gear is not centered, signals from the secondary coil of the followup transducer are summed by the amplifier to center the nose gear and prevent wheel caster during the arrested landing.

With the nose gear steering system engaged, steering is accomplished by a servo control loop consisting of the nose gear steering input transducer, followup transducer, a nose gear steering amplifier, and the steering cylinder servo valve.

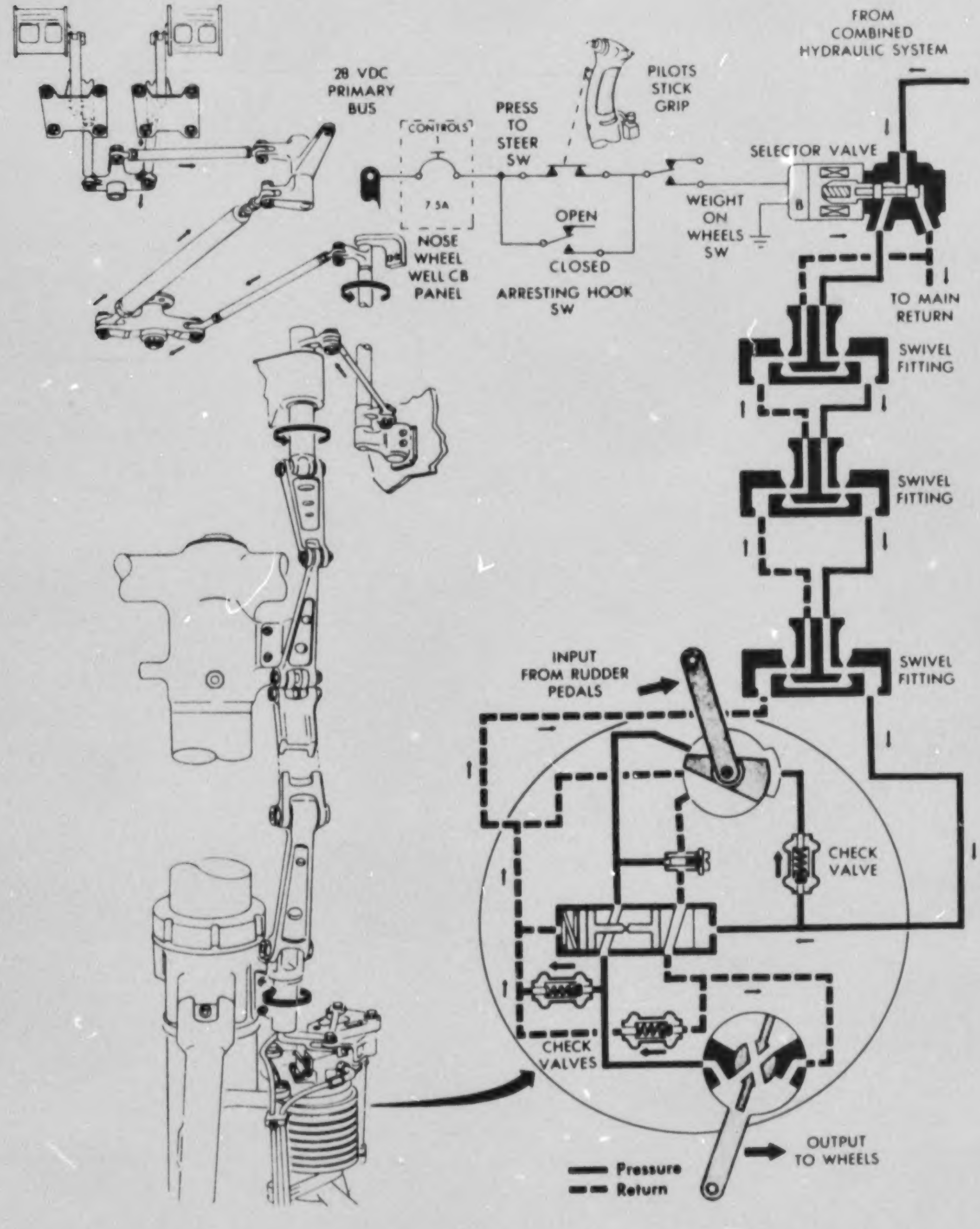
The nose gear steering input and followup transducers provide 400-Hz ac input signals to the amplifier. The transducer output signal is proportional to nose gear displacement right or left of center and is 180 degrees out of phase with the followup transducer signal. The ac signals are summed by the amplifier and converted to a dc signal with an average proportional to the summation. This signal is then applied to the steering cylinder servo valve, which is at the output of the amplifier. When the rudder pedals are deflected for a right or left turn, a differential voltage is developed across the secondary coils of the transducers, which is applied to the amplifier resulting in a right or left turn in response to the servo valve.

As the gear reaches the steered position corresponding to rudder pedal deflection, the followup transducer applies a signal to the amplifier to avoid the amplifier output to the servo valve. The valve returns to a neutral position, hydraulically locking the steering cylinder in the desired position until a differential input voltage is again applied to the amplifier by rudder pedal deflection. If the rudder pedals are deflected to command a steering angle in excess of 61 degrees, the nose gear steering cutout switch is acutated to open when the gear exceeds 61 degrees. The gear selector valve is deenergized, and the system reverts to the damping mode of operation.

When the steering angle is decreased to less than 61 degrees, the cutout switch closes and steering is again available. The cutout switch is actuated by a cam on the nose gear strut. The steering system is automatically disengaged following takeoff by the weight-off relay. During retraction, the nose gear is automatically centered from any off-center position up to 61 degrees right or left of center by a cam and roller mechanism located on top of the shock strut inner cylinder while the cam is attached to the wheel well structure.

Damping is an internal function of the steering cylinder and is automatically in operation when the nose gear steering switch is released or steering limits are exceeded. Figure 8-9 shows how the damping action takes place. Under these conditions, the nose gear steering cylinder servo valve is deenergized, blocking flow of hydraulic fluid to and from the steering cylinder. The steering selector valve is deenergized and blocks the flow of hydraulic fluid to the servo valve and connects the servo valve pressure port to return.

A damper shutoff valve in the steering cylinder is spring loaded to the open position to interconnect the two sides of the cylinder piston chamber. Any erratic forces acting on the nose gear will tend to extend or retract the cylinder. Displaced fluid is transferred from one side of the cylinder piston to the other side through a damping orifice. The orifice restricts fluid flow rate, damping the forces acting on the nose gear.


FROM COMBINED HYDRAULIC SYSTEM
28 VDC PRIMARY BUS
CONTROLS
7.5A
NOSE WHEEL WELL CB PANEL
PRESS TO STEER SW
PILOTS STICK GRIP
OPEN
CLOSED
ARRESTING HOOK SW
WEIGHT ON WHEELS SW
SELECTOR VALVE
B
TO MAIN RETURN
SWIVEL FITTING
SWIVEL FITTING
SWIVEL FITTING
INPUT FROM RUDDER PEDALS
CHECK VALVE
CHECK VALVES
OUTPUT TO WHEELS
Pressure
Return

216.131

Figure 8-9.—Nosewheel steering system (A-6A).

Maintenance

Maintenance of the nose gear steering system consists of operational checks, bleeding the system, troubleshooting, and removal, installation, and adjustment of components.

OPERATIONAL CHECK.—An operational check is performed to ensure the quality of corrective or preventive maintenance according to the following steps:

1. Jack the complete aircraft.
2. Connect electrical power and external hydraulic power to PC-No. 2 hydraulic system.
3. Manually turn nose gear approximately 30 degrees to the right of center.
4. Actuate the nose gear steering switch and check that nose gear steering does not engage. (Reason—weight off wheels.)
5. Ensure that personnel and equipment are clear of the arresting hook. Extend the arresting gear and check that the nose gear returns to center.
6. Simulate weight on wheels by depressing the switch in the left wheel well, engage nose gear steering and partially depress the right rudder pedal. Check that the nose gear makes a partial right turn and stops.
7. Return the rudder pedals to neutral and check that the nose gear returns to within 0.15 inch of center.
8. Release the steering switch and check that the nose gear is held in the centered position.
9. Retract the arresting gear and repeat steps 6 and 7 except move the rudder pedal partially left.
10. Actuate the steering switch and slowly press the right rudder pedal for a full right turn. The triangular mark on the top front of the housing must be within ±0.2 inch of the right 61 degrees mark on the steering cap. Repeat this process with the left rudder pedal.
11. Manually turn the nose gear left, then right to the 0.3 inch beyond the 61 degrees index mark on the steering cap. With the steering switch actuated the system must be inoperative. (Beyond steering limits.)
12. With the rudder pedals in the clean configuration, move the nose gear left, then right to within 0.4 inch of 61 degrees limits and actuate the steering switch. The gear should return to neutral.
13. Release the weight-on-wheels switch and check that nose gear steering disengages.
14. Release the steering switch, remove rudder pedal rigging pin, and disconnect external electrical and hydraulic power.
15. Lower the aircraft and remove jacks.
16. Close access doors and check cockpit and nose gear well for cleanliness and loose gear.

TROUBLESHOOTING.—Troubleshooting is accomplished by studying the system diagram and the related troubleshooting analysis chart, then systematically reasoning out the cause of the malfunction. Malfunctions listed in the troubleshooting tables for the A-7E are listed numerically and are related to a corresponding number or numbers following the steps of the operational checkout. If trouble symptoms are known, troubleshooting may be accomplished without reference to operational checkout. However, following system repair, the operational checkout must be performed to verify proper system operation.

BLEEDING.—Bleed the system every time a component is replaced or a line is disconnected. The nose gear should be cleared of the deck with hydraulic and electrical power connected. Depress the nose gear steering switch and operate the rudder pedals. As the nose gear steering cylinder extends and retracts, open and close the extend and retract bleed ports and relief valve bleed port at the steering cylinder until hydraulic fluid is free of air. Cycle the steering system 5 complete cycles. Secure the bleed ports and lockwire. Disconnect electrical and hydraulic power and remove the jack.

ADJUSTMENT.—Before adjustment is performed on the steering cylinder or amplifier, external hydraulic and electrical power is connected to the aircraft and then the nose gear is jacked clear of the deck. Adjust the steering cylinder in the following sequence:

1. Center nose gear.
2. Disconnect cylinder rod end from the steering linkage bellcrank.

3. Manually extend piston and position gage set on rod with gage flush with rod end.

Secure gage to rod end and push flush with cylinder housing.

4. Check to see that piston rod end will connect to steering linkage bellcrank with gear centered, and adjust rod end as required.

5. Remove gage set and attach piston rod end to steering linkage bellcrank.

To adjust the steering amplifier, proceed as follows:

1. Insert rigging pin No. 1 in rudder pedal linkage and check that rudder is in contour neutral.

2. Actuate steering switch and check that gear is centered within 2 degrees of center index mark.

3. If gear is not centered within limits, adjust steering amplifier potentiometer R7 so that the circuit is balanced.

4. Remove rigging pin and check rudder pedal area and LOX area for foreign objects.

5. Remove jack and external power.

NOTE: Electrical adjustments are accomplished by personnel of the AE Rating.

MECHANICALLY CONTROLLED NOSE STEERING SYSTEM

The A-6A nose steering system is mechanically controlled and hydraulically actuated in much the same manner as that previously described for the A-7E. The steering actuator is of a completely different design but serves the same dual function of providing steering and dampening, when steering is not engaged. Figure 8-9 illustrates the nose wheel steering schematic of the A-6A. Operation of the individual system components is covered in the Rate Training Manual for *AMH 3 & 2.*

Operation

With 28 volts dc power and combined hydraulic system pressure available, the steering mechanism is pressurized automatically whenever the arresting hook is down and weight is on the wheels or by depressing the steering switch on the control stick grip. Either method provides hydraulic pressure through the energized steering selector valve to the rotary vane-type steering/dampener assembly.

The steering assembly is controlled by linkage attached to the rudder pedals in the cockpit. When the pedals are moved, they cause the internal control valve of the assembly to direct pressure to the right or left side of the cylinder vanes. The output arm, attached to the lower portion of the strut, rotates the nosewheels in porportion to rudder pedal movement. The mechanical input provided by the rudder pedal linkage requires 5 inch-pounds of torque to achieve an output torque of 12,000 inch-pounds minimum. The output arm of the steering assembly is returned to neutral by the torsion spring, torsion bar, and bracket assembly which encircles the exterior body of the actuator.

When pressure to the steering assembly is cut off, the selector valve opens the system to return, and the spring in the steering assembly internal valve positions the valve to the dampening position by connecting the two sides of the steering vanes through the dampening restrictors.

Maintenance

Maintenance of the A-6A nose steering system closely parallels that previously covered on the A-7E and consists generally of operational testing, troubleshooting, rigging, and lubrication, and removal, replacement, and repair of components.

RIGGING.–Rigging of the control linkages, shown in figure 8-9, consists of jacking the nose of the aircraft, operating the rudder pedals to deplete hydraulic pressure, and centering the recoil strut manually so that the link arm is in line with the centers of the strut and the steering assembly. All lower links are adjusted to move freely overcenter to ensure that parts are free from binding and then locked in place with the stops. Rigging pins are installed in the rudder pedal to nose steering assembly linkages, with the rods being adjusted to accommodate the installation of the pins. Following adjustment of the linkage, the rigging pins are removed and the system checked for proper operation.

STEERING ASSEMBLY MAINTENANCE.–O-rings, packings, and miscellaneous parts within the steering assembly can be replaced at the intermediate level of maintenance. Trouble analysis charts are provided in many of the Maintenance Instructions Manuals and 03 Manuals to accommodate the systematic checkout of individual components in much the same manner as complete aircraft systems are checked out. Like the aircraft troubleshooting charts, they are based on manufacturer's experience, past component discrepancies, and component design. They list many of the possible troubles, probable causes, and recommend a common sense remedy.

Disassembly of the steering dampener assembly is accomplished in the order of the key index numbers assigned to the exploded view illustration of the assembly provided in the Intermediate Repair Section of the MIM. Prior to reassembly, all parts are cleaned with a suitable solvent such as trichlorethylene and air dried with warm, dry, low-pressure (10 psi) air. Nylon, rubber, and teflon parts are replaced and not cleaned. All parts of the steering assembly are inspected, utilizing the inspection standards provided in the MIM or applicable 03 Manual, for minimum acceptable service limits.

Reassembly is essentially a reversal of the disassembly order with appropriate quality assurance checks at specific steps. Following complete reassembly the steering assembly must undergo the following bench tests:

1. Proof pressure test.
2. Input torque test.
3. Steering resolution test (input motion versus output motion).
4. Stall leakage test (output shaft in neutral and input shaft fully engages–measure leakage).
5. No steer test (steering assembly in neutral–measure leakage at return).
6. External leakage test.
7. Static friction torque test (Clockwise and counterclockwise torque required to start movement of the output shaft in the power ON and power OFF conditions).
8. Output torque test.
9. Steady dampening rate test.

The numerous steps involved in bench testing components such as the steering assembly and the variations between it and other steer actuators make it impractical to cover the individual steps in detail. The importance of ensuring that each component repaired at the intermediate maintenance level is actually in a Ready For Issue condition requires constant vigilance on the part of the shop supervisor and quality assurance personnel. A complete and thorough, by the book, bench test must be made in accordance with the test arrangements provided in the Maintenance Instructions Manual or the applicable 03 Manual.

CATAPULTING SYSTEM

Nose landing gear catapult launching equipment such as that used on the A-6, A-7, and C-2 aircraft has streamlined the carrier launch operation. The AMH 3 & 2 Rate Training Manual provides coverage on the catapult system of the A-6. The A-7, while similar in most respects, has several design differences including hydraulic extension and retraction of the launch bar.

DESCRIPTION

As shown in figure 8-10, the system consists primarily of a launch bar (tow link), launch bar actuating cylinder, holdback tension bar socket assembly, centering spring, retracting springs, and a cockpit controlled selector valve. A launch bar warning light on the main instrument panel is illuminated any time the launch bar control switch is in EXTEND, the selector valve is in the bar extend position, the launch bar is not up and locked with weight off the landing gear, or the launch bar control switch is is RETRACT and the bar actuator is not up and locked. Two hooks are bolted to the nose gear trunnion to provide attaching points for the Short Airfield Tactical System (SATS) launching equipment.

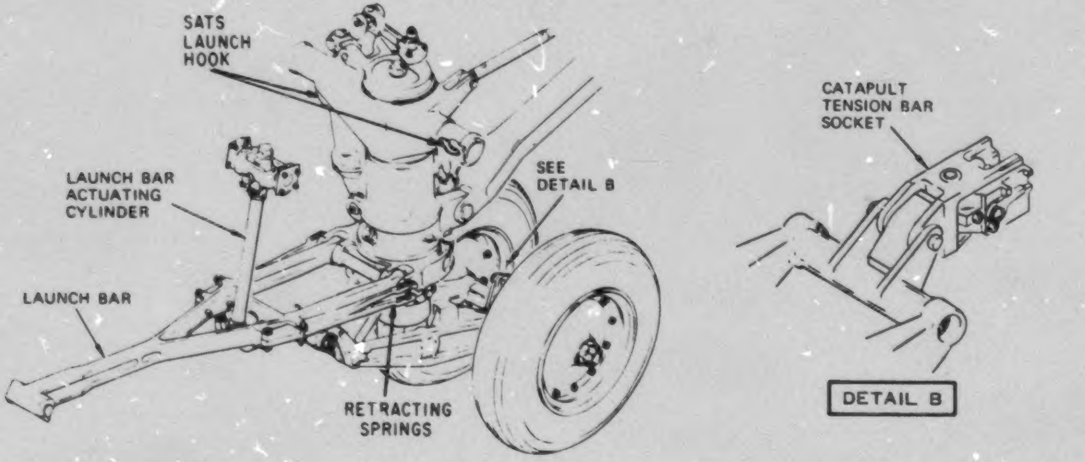


Figure 8-10.—Catapult system arrangement (A-7E).

OPERATION

Placing the launch bar control switch in EXTEND, with weight on the landing gear, completes the electrical circuit to the launch bar selector valve and directs pressure to unlock the locking fingers and extends the launch bar actuator rod. As the bar moves down, it encloses two horns on the nose gear axle beam enabling the launch bar to steer the nose gear.

As the aircraft approaches the catapult, the tension and holdback bars are attached to the tension bar socket. The launch bar enters the catapult track which permits the bar to steer the nose gear for alignment with the catapult. As the aircraft moves forward, the launch bar automatically engages the catapult shuttle. The shuttle is advanced to tension the aircraft on the catapult. The launch bar switch is placed in OFF, deenergizing the selector valve, thus connecting the launch bar actuator extend and retract ports to hydraulic return.

When catapult pressure reaches a predetermined value, the tension bar breaks and the aircraft is catapulted off the deck. The launch bar is held in the down position throughout the catapult run by the catapult shuttle. The bar is then released from the shuttle and the weight-on-gear switch is actuated to the weight-off-gear position. This completes an electrical circuit to energize the retract solenoid of the launch bar selector valve and port pressure to the launch bar actuator, automatically retracting and locking the bar. If automatic hydraulic retraction fails, the launch bar is raised by the action of the two leaf springs attached to each side of the launch bar. (See fig. 8-11.)

When the launch bar actuator piston is fully retracted, locking fingers on the piston lock the actuator and the bar in the retracted position. The launch bar may also be retracted by placing the cockpit control switch to RETRACT. To prevent damage to the bar and associated mechanism, the control switch should not be placed in RETRACT if the bar is restrained in the extended position. The actuator exerts approximately 400 pounds of retraction force in addition to leaf spring retraction force of 80 pounds.

MAINTENANCE

Maintenance of the catapult launching system consists of performing operational

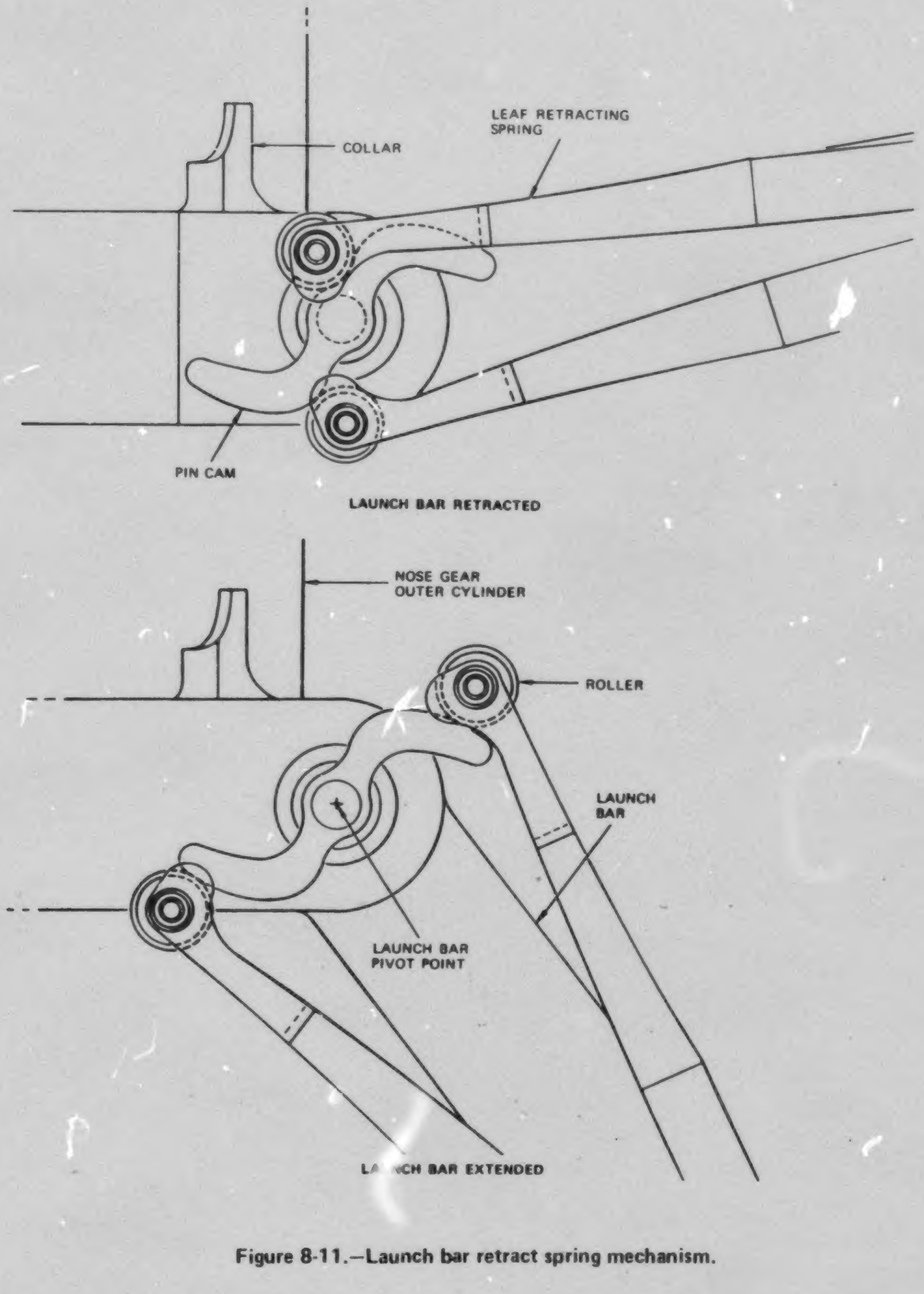

LEAF RETRACTING SPRING
COLLAR
PIN CAM
LAUNCH BAR RETRACTED
NOSE GEAR OUTER CYLINDER
ROLLER
LAUNCH BAR
LAUNCH BAR PIVOT POINT
LAUNCH BAR EXTENDED

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Figure 8-11.—Launch bar retract spring mechanism.

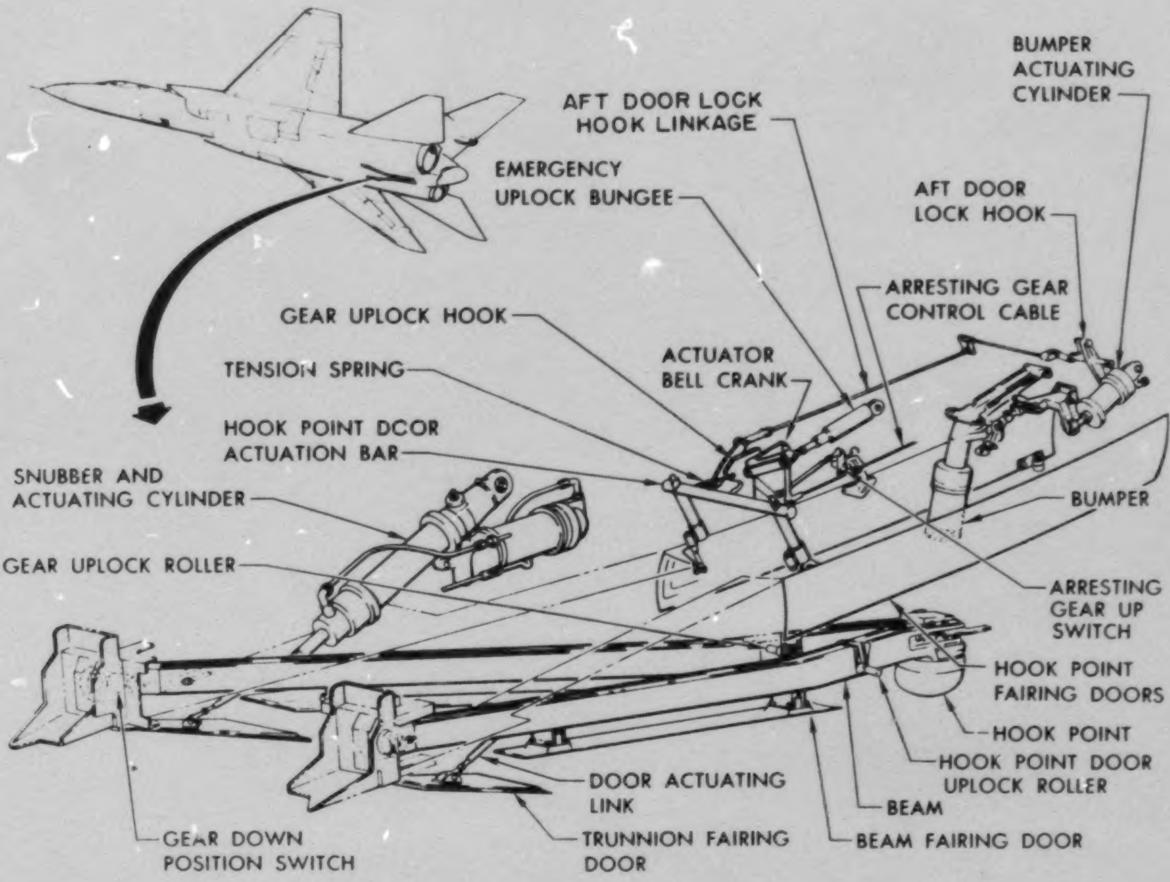
BUMPER ACTUATING CYLINDER
AFT DOOR LOCK HOOK LINKAGE
EMERGENCY UPLOCK BUNGEE
AFT DOOR LOCK HOOK
ARRESTING GEAR CONTROL CABLE
GEAR UPLOCK HOOK
ACTUATOR BELL CRANK
TENSION SPRING
HOOK POINT DOOR ACTUATION BAR
SNUBBER AND ACTUATING CYLINDER
BUMPER
GEAR UPLOCK ROLLER
ARRESTING GEAR UP SWITCH
HOOK POINT FAIRING DOORS
HOOK POINT
HOOK POINT DOOR UPLOCK ROLLER
DOOR ACTUATING LINK
BEAM
GEAR DOWN POSITION SWITCH
TRUNNION FAIRING DOOR
BEAM FAIRING DOOR

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Figure 8-12.—Arresting gear installation.

checkouts, troubleshooting, inspection, removal, installation and repair of components, and rigging of the launch bar actuator so that the launch bar rests in the fuselage recess when the nose gear is retracted.

The operational checkout is performed to ensure the quality of corrective and preventive maintenance, and the entire check requires verification by a quality assurance inspector.

Inspections include checking the SATS hooks after every 10 SATS takeoffs, operationally checking the system for proper operation prior to deployment or carrier assignment, and an indepth inspection of the aircraft in accordance with the Maintenance Requirements Cards whenever a hard catapult launching is reported.

Scheduled maintenance specified on the Maintenance Requirements Cards for the catapulting system in general calls for lubrication of the shuttle bearing surfaces every ten launches, removal and inspection or overhaul of certain load-bearing components each 100 launches, and scrapping of these components after a varying number of launches ranging from 1,000 to 1,500 launches.

ARRESTING GEAR

The arresting gear system controls operation of the arresting hook and the supplementary equipment required to lower and raise the hook for carrier operation. The arresting gear system shown in figure 8-12 is installed in the A-5 aircraft.

DESCRIPTION/OPERATION

This system consists of an arresting hook, snubber-actuator, arresting gear selector valve, arresting hook control handle, arresting hook bumper and bumper actuator, arresting hook point doors and the necessary cables, mechanical linkages, and switches. The pilot controls the system electrically and mechanically by use of the ARREST HOOK control handle located in the pilot's right-hand vertical panel.

Hook Extension

To extend the arresting gear, the ARREST HOOK control handle in the cockpit is pulled out as far as it will go, approximately a 5-inch travel. On aircraft with Airframe Change, 293 incorporated, hook extension must be selected on the Hook Mode selector switch. A ratchet built in the handle mechanism, will hold the handle in this position until it is rotated and released to retract the gear. Pulling the ARREST HOOK control handle moves the actuating linkage to unlock the hook point fairing doors aft-unlock hook. At the same time, the linkage overcomes the tension spring, pulling the gear lock hook off the gear lock roller and allowing the gear to fall. (See fig. 8-13.) A time lag between the release of the aft doors unlock hook and the gear uplock hook is incorporated in the uplock mechanism to enable the doors to unlock and be in a position to be forced open by motion of the extending gear.

The hook point doors are maintained in the open position by means of an overcenter linkage and bungee force. Pulling the ARREST HOOK handle also actuates a switch, completing a circuit through the gear down position switch to turn on a warning light in the handle. This

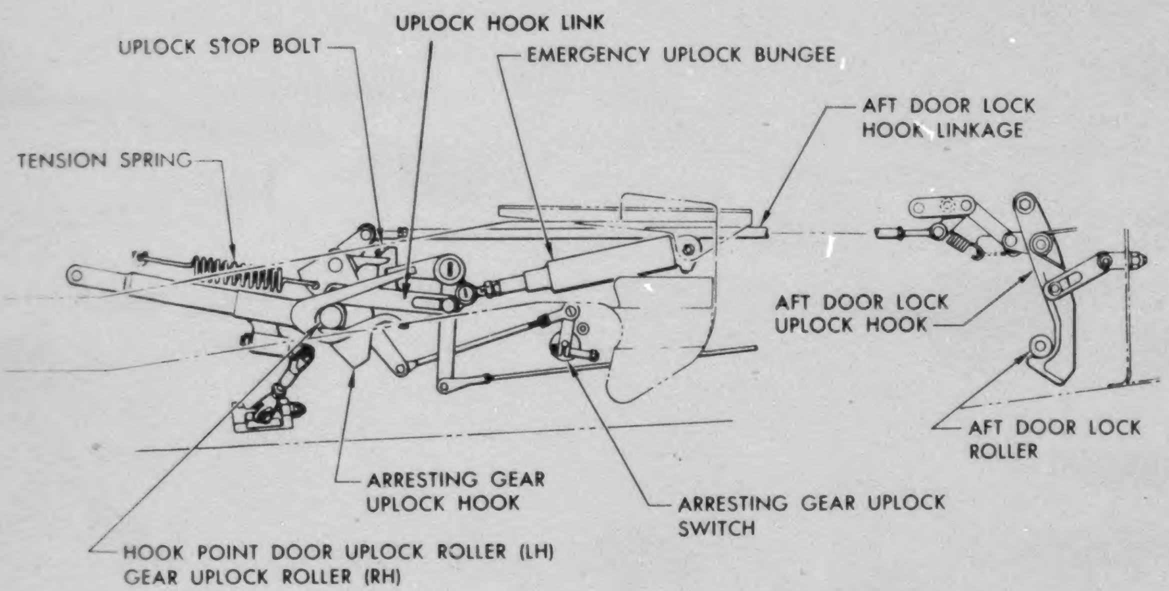
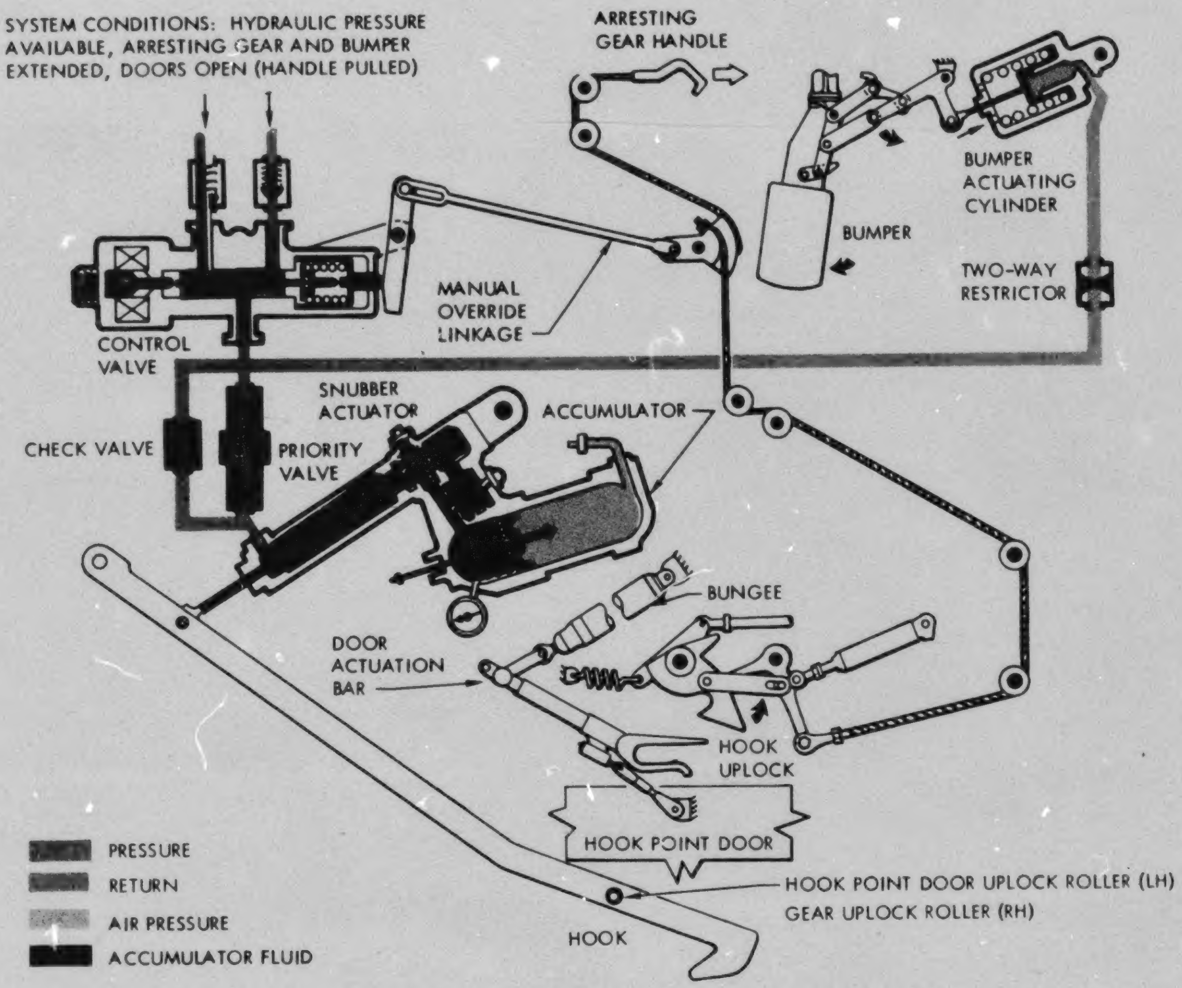

UPLOCK HOOK LINK
UPLOCK STOP BOLT
EMERGENCY UPLOCK BUNGEE
AFT DOOR LOCK HOOK LINKAGE
TENSION SPRING
AFT DOOR LOCK UPLOCK HOOK
AFT DOOR LOCK ROLLER
ARRESTING GEAR UPLOCK HOOK
ARRESTING GEAR UPLOCK SWITCH
HOOK POINT DOOR UPLOCK ROLLER (LH)
GEAR UPLOCK ROLLER (RH)
216.135

Figure 8-13.—Arresting gear hook and door uplocks.


SYSTEM CONDITIONS: HYDRAULIC PRESSURE AVAILABLE, ARRESTING GEAR AND BUMPER EXTENDED, DOORS OPEN (HANDLE PULLED)
ARRESTING GEAR HANDLE
BUMPER ACTUATING CYLINDER
BUMPER
TWO-WAY RESTRICTOR
MANUAL OVERRIDE LINKAGE
CONTROL VALVE
SNUBBER ACTUATOR
ACCUMULATOR
CHECK VALVE
PRIORITY VALVE
BUNGEE
DOOR ACTUATION BAR
HOOK UPLOCK
HOOK POINT DOOR
HOOK POINT DOOR UPLOCK ROLLER (LH)
GEAR UPLOCK ROLLER (RH)
HOOK
PRESSURE
RETURN
AIR PRESSURE
ACCUMULATOR FLUID

216.136

Figure 8-14.—Arresting gear schematic.

warning light indicates the hook is not fully down with the handle pulled.

The arresting hook is extended by gravity, assisted by the accumulator action of the snubber-actuator. (See fig. 8-14.) The extended position of the hook is limited by the travel of the piston in the snubber-actuator. On aircraft having Air Frame Change 293 incorporated, the travel of the piston within the snubber-actuator is controlled to permit two-position extension—(1) 55 degrees for normal carrier landings, and (2) 35 degrees for emergency field landings. As the hook falls out of the uplock, a striker arm mounted on the arresting hook point strikes a trigger which moves the bumper mechanism overcenter, allowing the spring-loaded bumper actuator to extend the bumper. As the arresting gear reaches the fully down position, the gear down switch deactuates, opening the circuit to the handle warning light, causing the light to go out. The arresting gear selector valve remains deenergized, with the return side open during the entire extension cycle.

Hook Retraction

To retract the hook, the hook handle is rotated 90 degrees clockwise. Rotation of the handle disengages the ratchet and allows the handle to return to the normal or retract position, permitting the uplock hooks for both the doors and the arresting hook to return to the locked position. Also, the arresting hook handle switch is actuated, completing a circuit through the door position switch and the hook up position switch to illuminate the warning light and energize the arresting gear selector valve. The valve, when energized, ports hydraulic pressure to the bumper actuator and through a priority valve to the snubber-actuator. The bumper actuator moves the bumper to the up and overcenter position.

Since the doors are locked open and cannot close, pressure builds up until the priority valve opens, directing pressure to the snubber-actuator. The snubber-actuator retracts the arresting hook. As the gear retracts, a roller on the left-hand gear beam engages the actuating bar linkage and moves the linkage from the overcenter position, forcing the doors to close as the gear continues to retract.

As the hook goes to the up-and-locked position, the uplock roller cams the uplock hook back against spring pressure until the roller reaches the throat of the hook. Spring pressure then pulls the hook to the locked position, locking the hook up and actuating the hook up position switch. As the hook point doors near the closed position, the door lock rollers engage and cam back the aft door lock hook. As the doors fully close, a spring moves the hook to engage the rollers and lock the doors closed. Actuation of the arresting gear uplock switch deenergizes the selector valve, returning the valve to the closed position. Also at the same time, the circuit to the warning light is broken and the light goes out.

Emergency Operation

A separate emergency system is not provided as such. There are, however, several emergency features incorporated in the arresting hook system. The arresting gear selector valve is in the gear extend position whenever it is deenergized. To ensure that the hook will extend even if the valve becomes stuck in the energized (retract) position, a mechanical override linkage is provided on the valve. This linkage is connected to a sector which rotates whenever the arresting hook is extended.

Another emergency feature to ensure extension of the hook is the presence of a priority bypass line incorporating a check valve. With the ARREST HOOK handle pulled to initiate extension of the gear, return pressure from the retract side of the snubber-actuator will bypass the priority valve if the valve malfunctions.

To provide for uplock hook operation in case of cable breakage, an emergency override bungee is built into the uplock linkage. This bungee will force both the door and the hook uplocks to the unlocked position if the cable breaks. With the hooks unlocked, the hook up position switch and the door position switch will be deactuated. If the ARREST HOOK handle is in, the warning light in the handle will come on and the arresting gear control valve will be energized. At the same time the bungee forces the hooks to the unlocked position, it pulls the cable that connects the control sector to the handle. The valve override mechanism is operated by rotation of the control sector. If the cable breaks between the arresting gear handle and the control sector, action of the emergency override bungee will pull the cable and rotate the control sector. The valve override mechanism will operate the valve mechanism to the extend position even though the solenoid is energized. If the cable breaks between the emergency override bungee and the control sector, the hook and door uplocks will be released by the control sector will not be rotated. In this case, the valve will be energized and pressure will be ported to hold the hook and the doors in the up position. When the handle is pulled to extend the hook, the handle switch will be deactuated, the valve will be deenergized, and the doors will open and the hook will drop in a normal manner.

MAINTENANCE

Maintenance of the arresting gear system at organizational maintenance levels consists of servicing the snubber-actuator and bumper assemblies, operational checks, troubleshooting, rigging and adjusting the system, and removal and installation of components within the system.

The following warnings should be observed by all personnel who are assigned maintenance tasks on the arresting gear system:

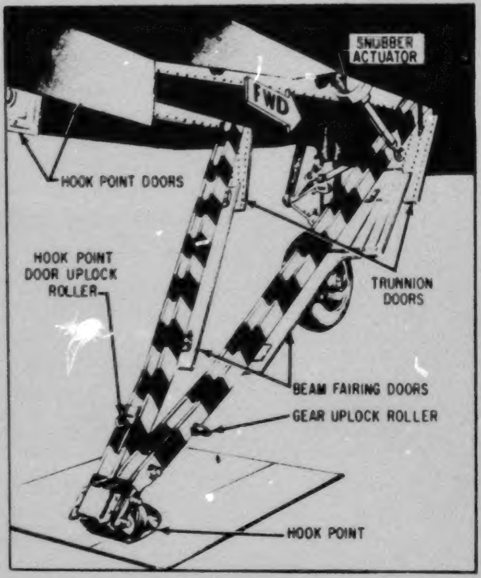
Before operating the arresting gear, make sure all personnel and equipment are clear of the area through which the gear moves.

When checking arresting gear operation, always provide suitable protection for the arresting hook point. Place a sandbag or padding on the deck.

Snubber-Actuator Assembly

The arresting hook snubber consists of an actuating cylinder with an attached accumulator. See fig. 8-14. The fluid chamber of the accumulator is interconnected to the extend side of the actuator section. The snubber-actuator utilizes hydraulic pressure to retract the arresting hook. As the hook is retracted, fluid behind the piston is forced into the accumulator. When the arresting hook is released, accumulator pressure (plus gravity) causes the snubber-actuator to extend.

On aircraft having Airframe Change 293 incorporated, a new snubber-actuator is installed which has a position-actuating piston located perpendicular to the snubber-actuator piston on the return side. When the "FIELD-35°" position is selected, pressurized hydraulic fluid is ported into the actuator, forcing the piston against the spring-loaded extrusions of the rotating piston stop. The snubber-actuator piston shaft passes the 55° position and moves through slots to the 35° position stop. The hook extension is controlled by the size of the return line which restricts fluid flow from the retract side of the piston. The retract side of the actuator piston is connected to the return line through the arresting gear control valve (selector valve). An air pressure gage, an air filler valve, an indicator rod, and hydraulic fill and bleed fittings are included on the assembly for servicing the unit.



216.137

Figure 8-15.—Arresting hook assembly.

A repair kit is provisioned for fleet repair of this assembly. The kit contains certain replacement parts which can be installed without removing the assembly from the aircraft. If additional repair work is required of the assembly, it should be removed and replaced with a like serviceable item.

Arresting Hook Assembly

The arresting hook (fig. 8-15) is the V type, consisting of two I beams with trunnions at the open end of the V and a hook point at the apex. Replacement of the hook point is possible without removing the hook assembly from the aircraft. The hook assembly is faired into the fuselage by three sets of doors. A pair of doors fairs the trunnions and is actuated by link rods attached to the hook assembly. Another pair of doors is attached to and operated with the gear beams. The third set fairs in the hook point with the fuselage. These doors are actuated by a roller on the hook trunnion beam picking up an actuating bar linkage attached to the doors.

The Periodic Maintenance Information Cards for each aircraft and NAVAIR Instruction 13430.1 (Series) provide detailed information on the inspection, replacement, and disposition of arresting hook assemblies after a specified number of arrested landings. The inspection and replacement interval is dependent on the type of hook.

There are currently three types of arresting hooks. Type I integral type arresting hook is highly heat-treated with an uncoated hook point. Type II integral type has a Metco coated hook point. Type III detachable hook point is heat-treated stainless steel or alloy, coated with Colmony or Metco.

As an example the A-6 aircraft has the Type II hook assembly. The conditional Maintenance Requirements Card for the A-6 requires inspection of the arresting hook stinger and centering block after each 10 recorded arrestments. The inspection consists of the following:

1. Checking the hook shank, centering block, and truss members for cracks, misalignment, and obvious damage.
2. Checking the stinger (I-beam and hook point) for transverse cracks in the Metco coating, extending to the base metal.
3. Chipping or gouging in cable contact groove.
4. Cracks or defective bonding of the Metco coating.

Any of these conditions are cause for rejection and replacement of the assembly.

To determine if cracks extend into the base metal, a copper sulfate solution consisting of 25 grams of copper sulfate, MIL-O-C828A, dissolved in 100 cc of distilled water and 3 cc of sulfuric acid is applied to the crack. A deposit will form on the steel base metal but not on the Metco coating.

Following inspection or installation of a new arresting gear assembly, apply grease conforming to that recommended by the applicable MRC and/or the Maintenance Instructions Manual to the cable groove area.

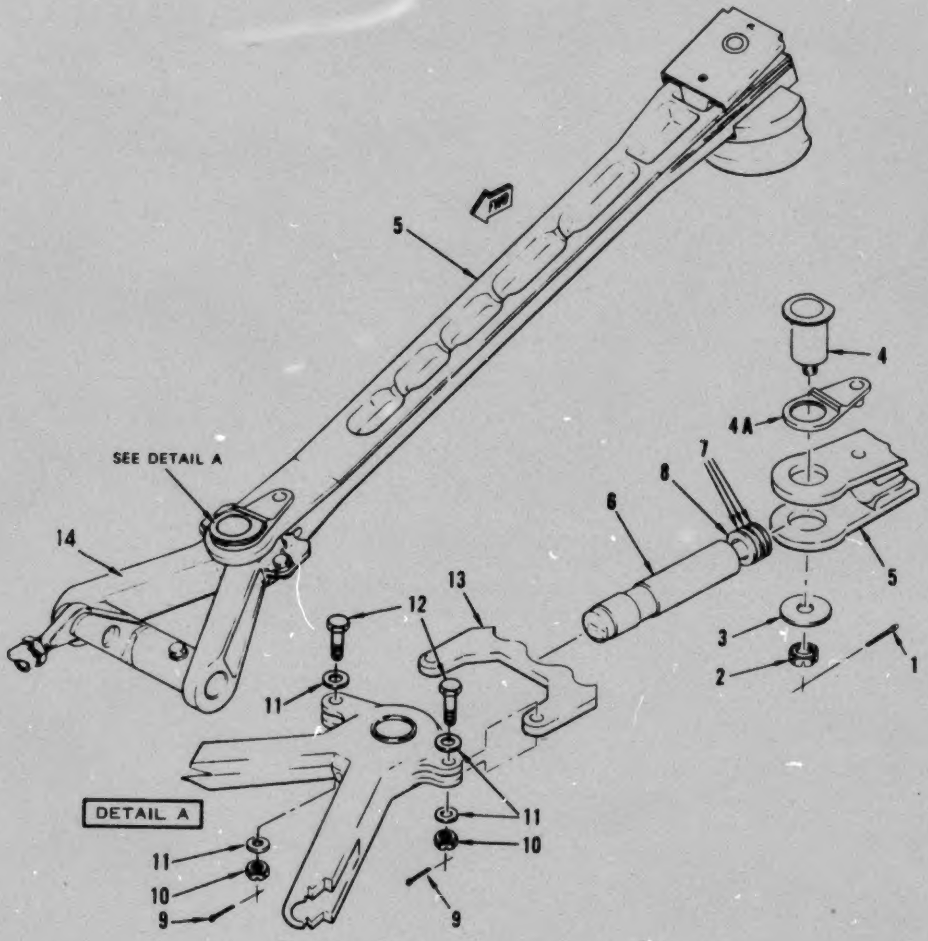
Whenever the arresting hook has been subjected to a double wire engagement, strikes the ramp or a deck protrusion, or approaches, but does not exceed 100 arrestments, designated parts of the complete arresting gear mechanism must be replaced. The removed parts are forwarded to the designated depot level maintenance activity for test and overhaul. The total number of arrestments should be included on the screening and ready-for-issue tags so that an accurate account of the total number of arrestments of each assembly can be maintained.

Detachable hook points that are removed for inspection after 10 arrestments are reinstalled or replaced using new attaching hardware (nut, bolt, washer, etc.). Ensure that the bolt is installed with the head down and the nut on top. In all cases, periodic maintenance of the arresting hook assemblies should be in accordance with the applicable Maintenance Instructions Manual, Maintenance Requirements Cards, and NAVAIR Instruction 13430.1 (Series).

SINGLE SHANK CENTERING DEVICES

Single shank type arresting hook assemblies, such as that used on the A-7 and the F-4 aircraft, must be held in the centerline position for retraction in their fuselage recesses and prevented from side movement during carrier arrested approaches.

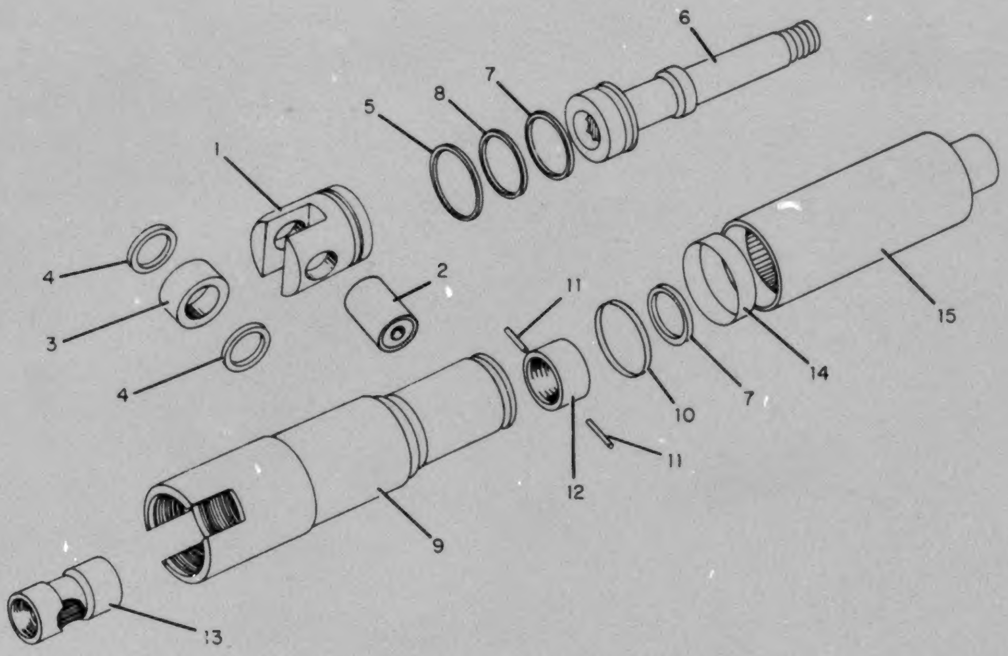
The A-7 arresting gear mechanism (fig. 8-16) utilizes a liquid spring for this purpose. The spring is located within a recess of the hook shank and the keyed end presses against the


5
4
4A
7
8
6
SEE DETAIL A
14
13
12
5
3
1
2
11
DETAIL A
11
10
11
10
9
9

1. Cotter pin.
2. Nut.
3. Washer.
4. Pin.
4A. Index arm.
5. Shank.
6. Liquid centering spring.
7. Shims.
8. Spacer.
9. Cotter pin.
10. Nut.
11. Washer.
12. Bolt.
13. Centering cam.
14. Drag link.

216.143

Figure 8-16.—Arresting gear mechanism (A-7).



1. Cap.
2. Roller, boss cap.
3. Roller, tire cap.
4. Seal cap.
5. Seal cap.
6. Stud.
7. Seal, stud and piston
8. Seal, stud.
9. Piston.
10. Seal, piston.
11. Pin, dowel, valve.
12. Valve stop.
13. Valve slide.
14. Seal, cylinder.
15. Cylinder.

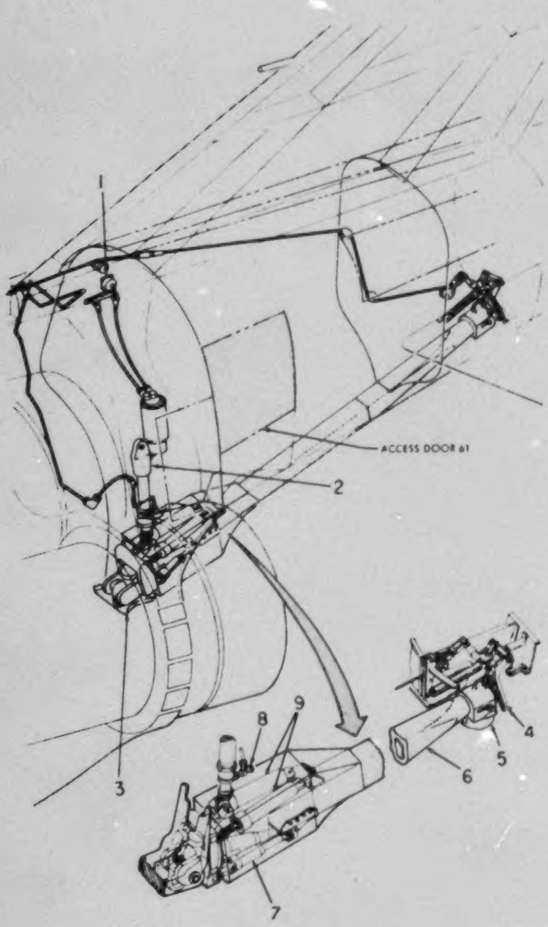
216.144

Figure 8-17.—Liquid spring shock assembly.

centering cam (13). On installation, the spring is shimmed (7) until the thickness of the spacer (8) and shims is approximately 0.125 inch. The spring is installed in the shank and then the shank is secured to the drag link (14). The hook point is checked for excessive side play; and if side play exceeds 0.24 inch, more shims must be added to the spring. The total thickness of shims must not exceed 0.185 inch. Any time shim thickness exceeds 0.150 inch the hook must be moved laterally several times in each direction to ensure that the hook can move 40 degrees left and right without bottoming out the liquid spring.

While liquids are normally thought of as incompressible, the action of the liquid spring is based on the slight compressibility of liquids. Figure 8-17 illustrates the disassembled spring assembly. Most of the internal parts are classified as nonrepairable, and damage will require replacement at depot level maintenance.

The spring assembly contains 19 cubic centimeters of oil, MIL-S-21568. The oil is confined within the piston cylinder assembly (9 and 15), and any side movement of the arresting hook shank must be against the compressibility of the oil. The maximum travel or



1. **Air pressure gage.**
2. **Vertical damper cylinder.**
3. **Fairing assembly.**
4. **Uplatch mechanism.**
5. **Hook point.**
6. **Hook assembly.**
7. **Horizontal damper.**
8. **Bleeder plug.**
9. **Centering springs.**

216.145

Figure 8-18.—Arresting gear assembly (F-4).

compressibility of the overall liquid spring assembly is 0.68 inch. The operating pressure within the assembly when bottomed out will be as high as 20,000 psi. In the static condition the oil trapped within the spring assembly is under a return preload pressure of 350 pounds, which is created by the reassembly of the close tolerance parts which confine the liquid.

The tolerances of parts within the liquid spring and the necessity to subject certain parts to approximately -110°F for varying lengths of time during the disassembly and assembly process make it impractical for it to be overhauled at the lower levels of maintenance.

The F-4 arresting gear assembly (fig. 8-18) employs a vertical damper cylinder (2) and two horizontal dampers (7) to dampen hook motion caused by deck impact forces. Two centering spring assemblies (9) maintain the hook in the center position.

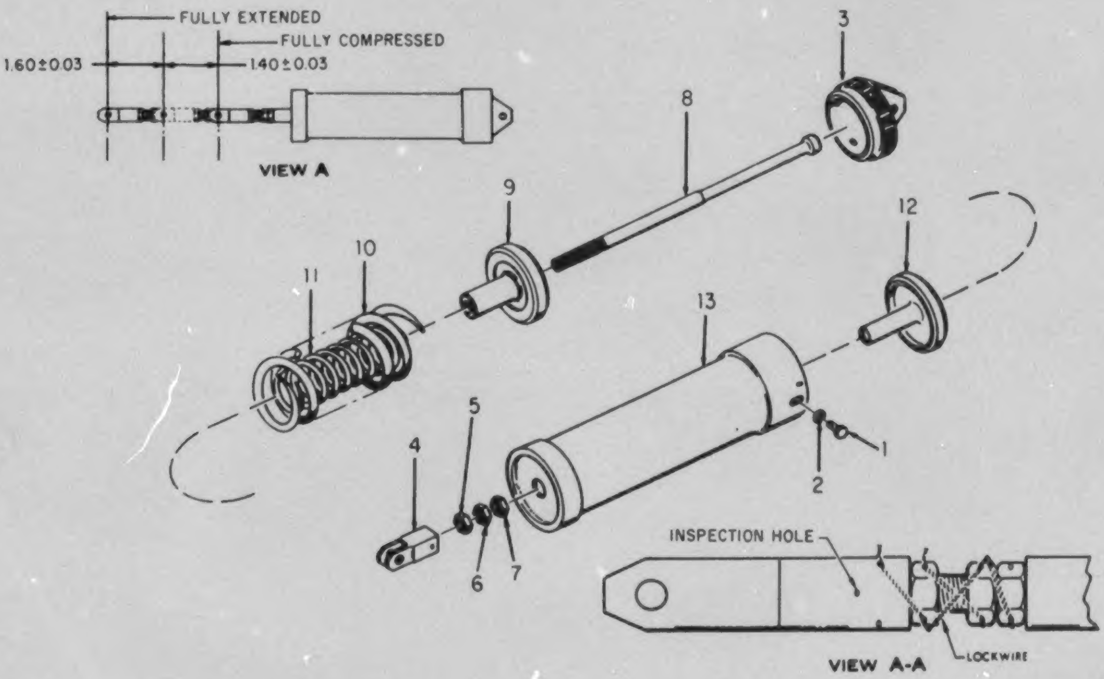
With the arresting hook lowered, the centering springs are adjusted in the following manner:

1. Center the hook assembly.
2. Adjust the rod ends of both centering springs to reach the attaching pivot holes. Threads must be visible through the rod end inspection hole (fig. 8-19).
3. The nuts on the attaching bolts are tightened fingertight and safetied with cotter pins.
4. Torque the rod end jamnuts to 270-300 inch-pounds and safety with lockwire as shown in figure 8-19.
5. Check lateral movement of the hook in accordance with the procedures prescribed in the Maintenance Instructions Manual.

Intermediate level maintenance of the centering springs consists of checking the disassembled parts for scoring, corrosion, nicks, and structural deformation or failure. Nonferrous parts are subjected to fluorescent penetrant inspection and ferrous parts to magnetic particle inspection. The diameter of all parts and the free length dimensions of the two springs (10/11) are checked against the values given in the parts tolerance tables provided in the MIM.

CAUTION: Disassembly and assembly require extreme caution. The spring force is in excess of 500 pounds.

Post-repair testing includes checking the breakout force required to extend and compress the springs. Force required is 560±60 pounds. The spring should extend 1.60±0.03 inch and compress 1.40±0.03 inch from neutral as shown in figure 8-19, view A.


FULLY EXTENDED
FULLY COMPRESSED
1.60±0.03
1.40±0.03
VIEW A
3
8
9
12
10
11
13
5
4
1
2
6
7
INSPECTION HOLE
LOCKWIRE
VIEW A-A

1. Bolt.
2. Washer.
3. End fitting.
4. Rod end.
5. Jamnut.
6. Jamnut.
7. Checknut.
8. Piston rod.
9. Support.
10. Outer spring.
11. Inner spring.
12. Plunger.
13. Shell.

216.146

Figure 8-19.—Centering spring (F-4).

CHAPTER 9

FLIGHT CONTROL SYSTEM MAINTENANCE

Flight control systems are classified as being either primary or secondary. Primary flight controls are those which provide control over the yaw, pitch, and roll of the aircraft. Secondary flight controls include the speed brake and flap systems. All systems consist of the control surfaces proper, the respective cockpit controls, connecting linkage, and other necessary operating mechanisms.

The systems discussed in this chapter are representative of those with which the hydraulics mechanic will likely be working. In parts of the discussion, fairly exact values such as tolerances, pressures, temperatures, etc., are given to provide realism in the coverage; however, the mechanic should bear in mind that changes in these values are sometimes necessitated as a result of later experience and data gathered from fleet use. Therefore, when actually performing the maintenance procedures discussed, the hydraulics mechanic should consult the current applicable technical publications for the latest information and exact values to be used.

PRIMARY FLIGHT CONTROL SYSTEMS

Power control systems are used on the latest high-speed jet aircraft. Aircraft traveling at or near supersonic speeds have such high airloads imposed upon the primary control surfaces that it is impossible for the pilot to control the aircraft without power-operated or power-boosted flight control systems. In the power-boost system, a hydraulically operated booster cylinder is incorporated within the control linkage to assist the pilot in moving the control surface. The power-boost cylinder is still used in the rudder control system of some high-performance aircraft; however, the other primary control surfaces utilize the full power-operated system. In the full power-operated system, all force necessary for operating the control surface is supplied by hydraulic pressure. Each movable surface is operated by a hydraulic actuator (or power control cylinder) incorporated in the control linkage.

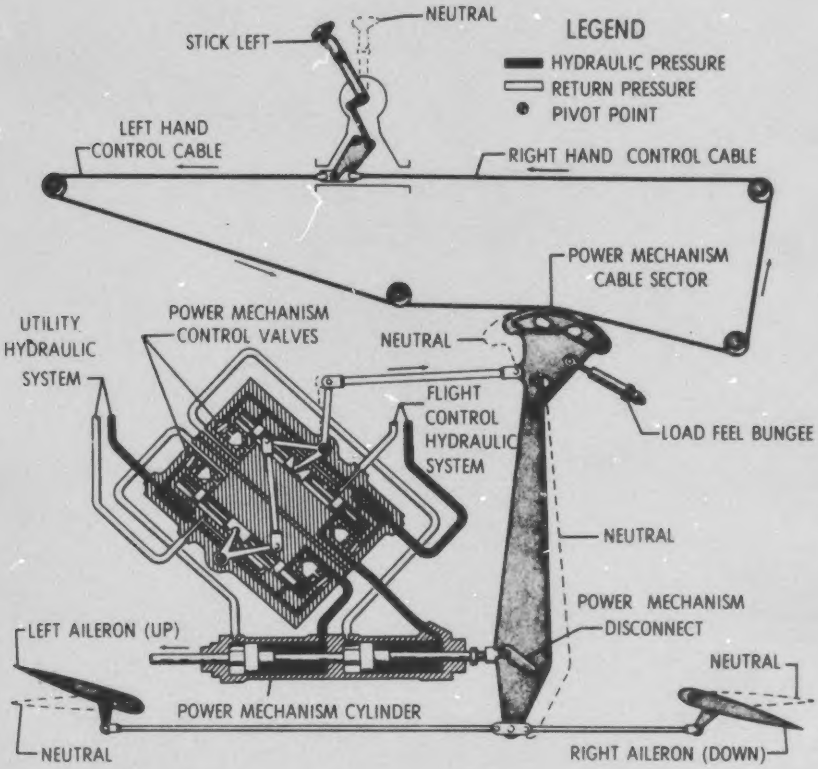
In addition to the current Navy specification requiring two separate hydraulic systems for operating the primary flight control surfaces, specifications also call for an independent hydraulic power source for emergency operation of the primary flight control surfaces. Some manufacturers provide an emergency system powered by a motor-driven hydraulic pump; others use a ram-air-driven turbine for operating the emergency system pump. Reference may be made to chapter 6 of this manual for a more complete coverage of hydraulic power systems.

LATERAL CONTROL SYSTEMS

Lateral control systems control roll about the longitudinal axis of the aircraft. In this section several of the different system arrangements utilized by aircraft manufacturers are described, and some of the maintenance requirements for primary flight control systems in general are discussed.

Aileron Control System (A-4)

The A-4E system is equipped with a power mechanism which provides hydraulic power to operate the ailerons. However, in the event of


NEUTRAL
STICK LEFT
LEGEND
HYDRAULIC PRESSURE
RETURN PRESSURE
PIVOT POINT
LEFT HAND CONTROL CABLE
RIGHT HAND CONTROL CABLE
POWER MECHANISM CABLE SECTOR
UTILITY HYDRAULIC SYSTEM
POWER MECHANISM CONTROL VALVES
NEUTRAL
FLIGHT CONTROL HYDRAULIC SYSTEM
LOAD FEEL BUNGEE
NEUTRAL
POWER MECHANISM DISCONNECT
LEFT AILERON (UP)
NEUTRAL
POWER MECHANISM CYLINDER
NEUTRAL
RIGHT AILERON (DOWN)

216.147

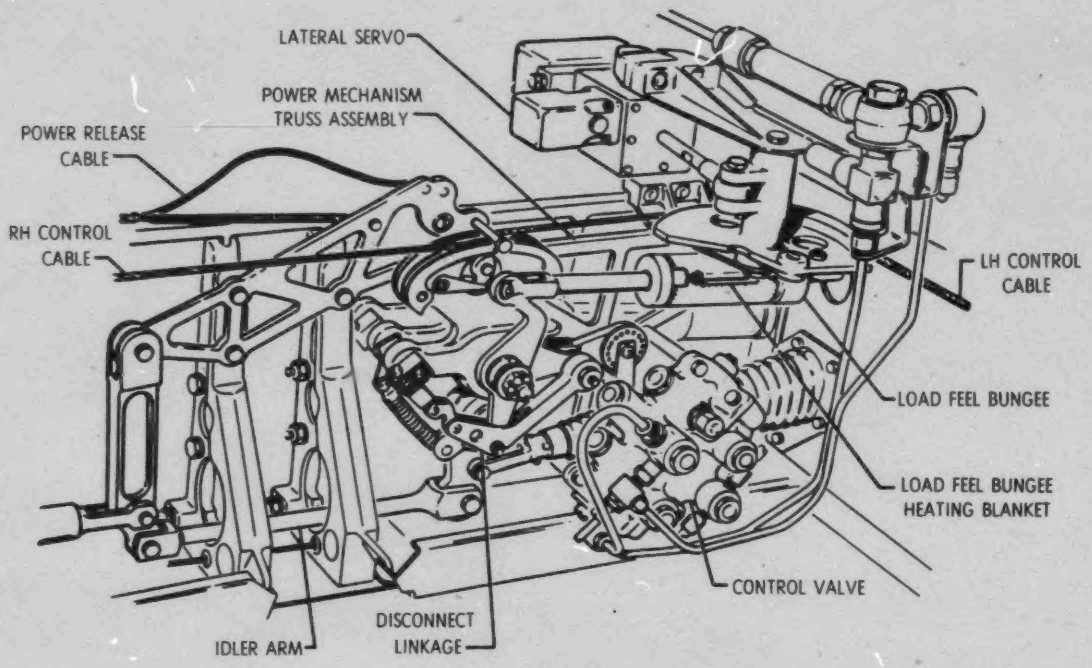
Figure 9-1.—Aileron control system—functional schematic.

hydraulic power failure, the mechanism can be disconnected, placing the system in complete manual operation.

OPERATION.—Operation of the aileron control system (fig. 9-1) is initiated when the control stick in the cockpit is moved to the left or to the right. When the stick is moved, cables connected to the bellcrank in the control stick housing are moved to actuate the sector on the power mecahnism. With the actuation of the sector, the power mechanism operates, transferring the movement to the mechanical linkage which in turn actuates the ailerons.

The aileron power mechanism (fig. 9-2) consists of two control valves, a dual-chambered hydraulic power cylinder, cable sectors, and a system of latches and related cranks. The control valves are connected in tandem by linkage. One valve is powered by the utility hydraulic system, and the other valve is powered by the flight control hydraulic system.

The power cylinder is a single, tandem cylinder, composed of four chambers with



216.148

Figure 9-2.—Aileron power mechanism—installation.

pistons connected to a common shaft. Each of the two control valves operates on that portion of the power cylinder to which it is associated. Both hydraulic systems operate simultaneously, and each delivers 3,000-psi pressure to the mechanism; however, if one hydraulic system should fail, the other system will supply sufficient power to operate the ailerons at reduced hinge movement.

When the control stick is moved, the control cables move the power mechanism sector. Through linkage, the sector actuates the control valves, which in turn direct hydraulic fluid to the power cylinder. The cylinder actuating shaft, which is connected to the power crank through a latch mechanism, operates the power crank. The crank moves the push-pull tubes, which actuate the ailerons. In the event of complete hydraulic power failure, a handle in the cockpit may be pulled to disconnect the latch mechanisms from the cylinder and load feel bungee. This places this particular aileron system in complete manual operation. In manual, the cable sector actuates the power crank.

This lateral control system incorporates a load feel bungee which serves a dual purpose. It provides an artificial feel and centering device for the aileron system, and is an interconnect between the aileron system and the aileron trim system. When the aileron trim actuator is energized, the bungee is moved in the corresponding direction and actuates the power mechanism, which repositions the aileron control system to a new neutral position.

An electric heating blanket is installed around the aileron load feel bungee to prevent its freezing when the aircraft is flying in the low temperatures found at higher altitudes.

In normal operation of the control system, when the control stick is actuated left or right, the power mechanism compresses the bungee. When the stick is released, the compressed bungee returns the stick to the neutral position.

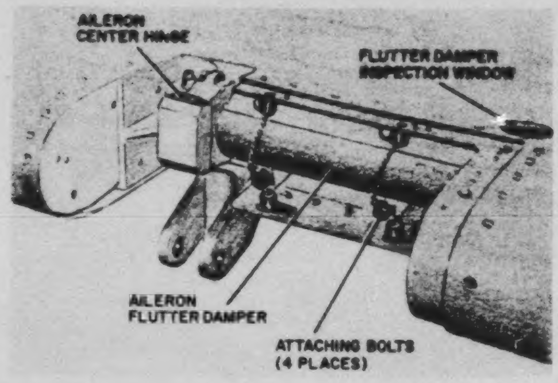
On later models and reworked A-4s, the bungee remains engaged at all times.

A rotary type flutter damper is installed in the leading edge of each aileron (fig. 9-3) and serves as the center hinge point. Inspection windows are installed on the ailerons to give a visual indication of the fluid level in the damper. The damper consists of a working chamber, wing shaft, abutments, automatic temperature compensating device, pressurized reservoir, and a fluid indicator.

The working chamber is divided into three sections by the wing shaft and the abutments. The motion of the aileron rotates the wing shaft relative to the abutments, causing a flow of fluid between the chambers. During normal rates of aileron travel, the fluid flows freely through orifices between the chambers. At accelerated aileron travel, such as flutter at high airspeeds, the orifices restrict fluid flow causing a dampening action against the flutter.

A spring-loaded piston, located in the reservoir chamber, pressurizes the fluid to ensure a constant fluid supply to the working chamber.

A fluid level indicator, located at the reservoir end of the damper, provides a visual indication of the reservoir fluid level. When there is a change of temperature on the unit, the automatic temperature compensating device varies the size of the orifices within the damper to compensate for the change.



216.149

Figure 9-3.—Aileron flutter damper.

Flaperon Control System (A-6)

The flaperon control system of the A-6 aircraft is an example of lateral control being provided by a hydroelectric mechanical flaperon system.

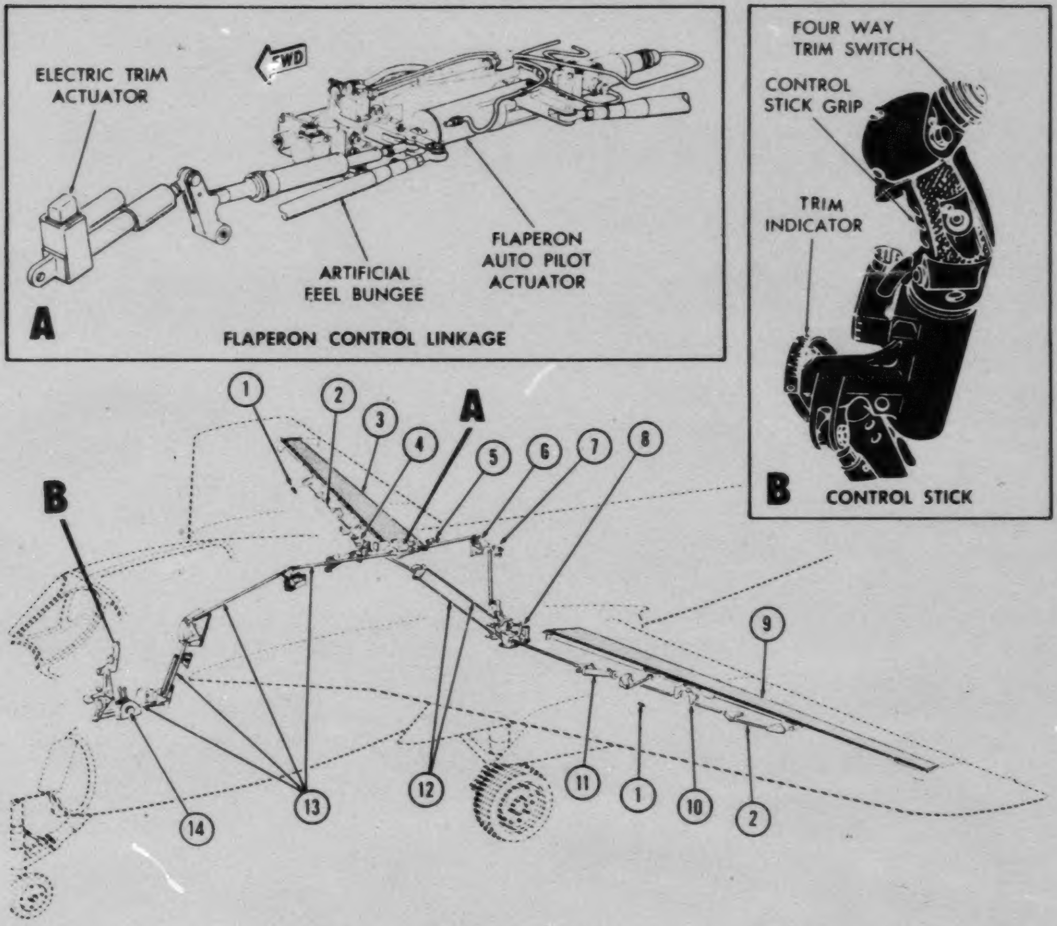
DESCRIPTION/OPERATION.—As shown in figure 9-4, the system includes an inboard and outboard flaperon for each wing and three actuators—a single flaperon autopilot actuator and a flaperon power actuator in each wing.

Control stick movement, left or right, raises the respective two flaperons, while the opposite two remain flush with the wing. Full throw of the control stick by the pilot causes the inboard flaperon to rise 49 1/2 degrees and the outboard flaperon to rise 53 degrees. In flight, the flaperon can also be positioned by Automatic Flight Control System (AFCS) electrical impulses, which are introduced at the autopilot actuator.

Control stick movements are transmitted through the pushrod and bellcrank system to the flaperon autopilot actuator. Mechanical outputs from this actuator are conveyed to a gearing mechanism at which point linkage to the left and right wing flaperon power actuators separates. The gearing mechanism transmits movement to the left or right flaperon, while maintaining the opposite flaperon flush with the wing. When the flaperon pop-up cylinder is actuated, the gearing mechanism transmits pop-up motion to each wing flaperon power actuator.

The semiautomatic flaperon pop-up device aids in reducing ground roll during landing. The pop-up system is activated by the pilot placing the pop-up switch in ARM. All flaperons will then automatically pop up approximately 41 degrees whenever weight is on the landing gear and the throttles are retarded. Mechanical interlocks prevent folding of the wings unless the flaperons are flush with the wings and also prevent flaperon pop-up operation when the wings are folded.

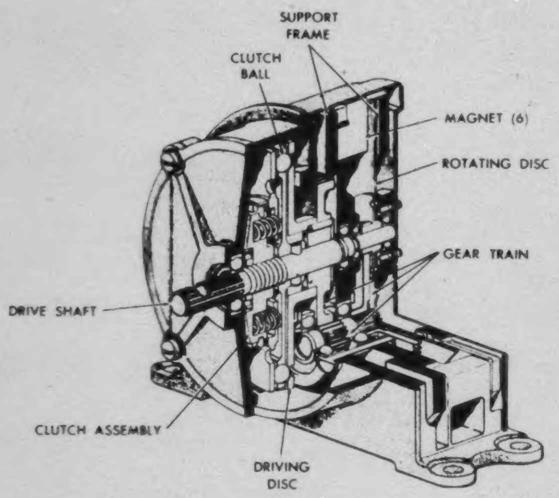
The eddy current damper (fig. 9-5) is mechanically linked to a bellcrank in the flaperon control linkage. It dampens any rapid left or right control stick inputs by producing an opposing force proportional to the speed at


ELECTRIC TRIM ACTUATOR
FWD
ARTIFICIAL FEEL BUNGEE
FLAPERON AUTO PILOT ACTUATOR
A
FLAPERON CONTROL LINKAGE
FOUR WAY TRIM SWITCH
CONTROL STICK GRIP
TRIM INDICATOR
B
CONTROL STICK
1
2
3
4
A
5
6
7
8
B
9
14
13
12
11
1
10
2

1. Wing fold flaperon interlock switch.
2. Flaperon control linkage.
3. Right wing flaperons.
4. Flaperon actuator (right wing).
5. Flaperon pop-up valve.
6. Wing fold interlock mechanism.
7. Filter.
8. Flaperon pop-up mechanism and cylinder.
9. Left wing flaperons.
10. Flaperon control linkage.
11. Flaperon actuator (left wing).
12. Cross over cables.
13. Pushrods.
14. Throttle quadrant.

216.150

Figure 9-4.—Flaperon control system (A-6).



216.151

Figure 9-5.–Eddy current damper.

which the stick is moved. The damper contains permanent magnets, a rotating copper disc, a gear train, and a clutch assembly. Control stick motion rotates the clutch and gear train which in turn rotates the copper disc. The copper disc is sandwiched in the airgap between the six permanent magnets and a flux plate. As the copper disc revolves, the magnetic field between the magnets and the flux plate is disturbed, causing an opposing force (eddy currents) that tends to stop the disc. The opposing force is proportional to the speed of the rotating disc and, therefore, the speed of stick movement. The clutch will slip at a force of 275-325 inch-pounds to prevent control stick binding in the event the damper jams.

Figure 9-6 illustrates the flaperon control system for the A-6. The flaperon autopilot actuator is powered by the flight hydraulic system and transmits mechanical inputs to the flaperon power actuators. The flaperon power actuators are tandem type and powered by the combined and flight hydraulic systems. They are capable of operating on only one system in the event of one system failing.

The artificial feel bungee provides an initial control stick preload and increased force feel over the full range of stick displacement.

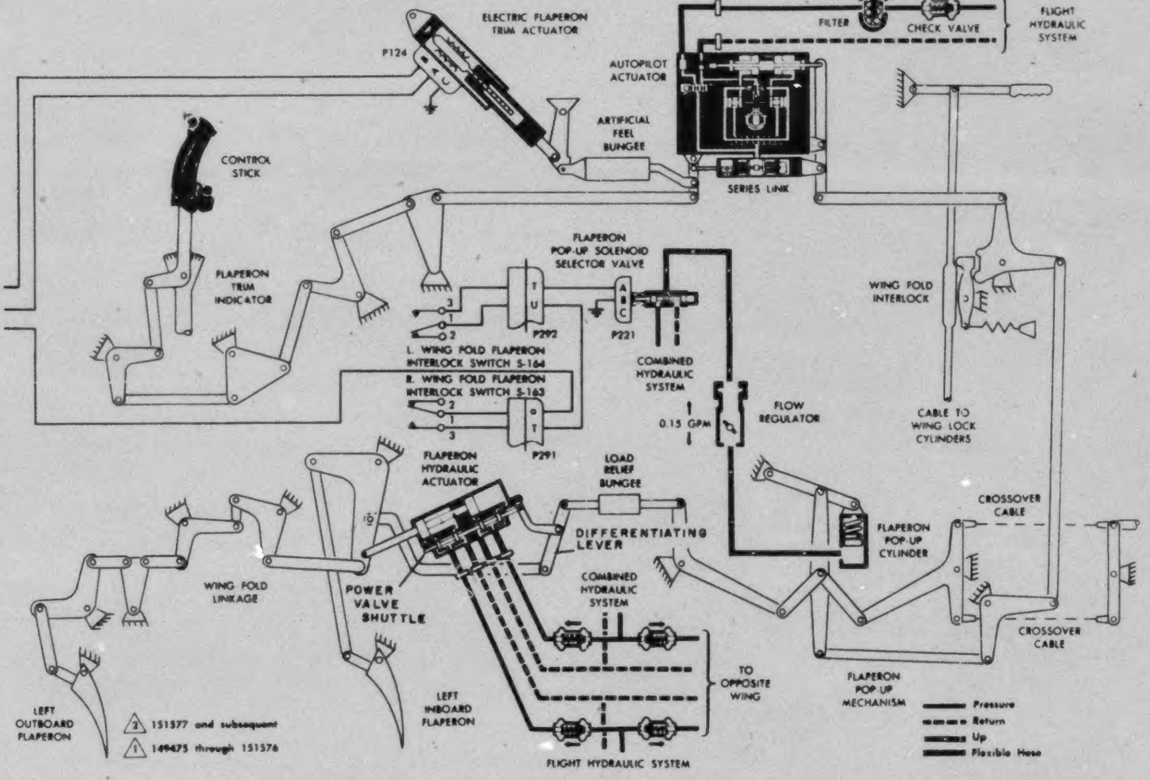
Lateral trim is provided by the electromechanical actuator which varies the neutral position of the artificial feel bungee. Trim is set using the switch on the control stick grip (fig. 9-4) and read on the mechanical flaperon trim indicator on the control stick.

FLAPERON AUTOPILOT ACTUATOR.–This actuator (figs. 9-6 and 9-7) contains an electrohydraulic servo valve, actuator pistons, solenoid valve, transducer, series link, and series-link rod. It indirectly controls flaperon movement in response to mechanical inputs from the pilot and electrical inputs from the automatic flight control system. The actuator can operate in two modes, manual or series.

In manual mode, the solenoid valve is deenergized and no fluid is ported to any portion of the actuator. The actuator piston rod is free to idle, and the series-link cylinder acts as a rigid link which transfers input lever motion to the output lever.

In series mode, the solenoid valve is energized and pressure is ported to the servo valve. Pressure from the servo valve drives the actuator pistons together, causing the pistons and the rod to act as one piece. When the servo valve is at null, pressures in the piston end chambers are equal. Electrical signals from the automatic flight control system cause the electrohydraulic servo valve to differ the pressures in the end chambers, thus providing the working force for the actuator. The actuator piston rod drives the output lever. Pressure at the series link compresses a lockspring, unlocking the series link so that the actuator can stroke the pilot commanded piston. When the pilot moves the input link, relative motion between input and output causes the transducer to send a signal to the AFCS amplifier. The signal is combined with other flight stability signals, and the resultant signal is used to operate the servo valve. The AFCS can be overridden by the pilot applying a stick force of 25 pounds.

FLAPERON ACTUATORS.–The flaperon actuators directly control the flaperon


ELECTRIC FLAPERON TRIM ACTUATOR
P124
FILTER
CHECK VALVE
FLIGHT HYDRAULIC SYSTEM
AUTOPILOT ACTUATOR
ARTIFICIAL FEEL BUNGEE
CONTROL STICK
SERIES LINK
FLAPERON TRIM INDICATOR
FLAPERON POP-UP SOLENOID SELECTOR VALVE
T
U
A
B
C
3
1
2
P292
P221
L. WING FOLD FLAPERON INTERLOCK SWITCH S-164
R. WING FOLD FLAPERON INTERLOCK SWITCH S-163
2
1
3
T
P291
WING FOLD INTERLOCK
COMBINED HYDRAULIC SYSTEM
0.15 GPM
FLOW REGULATOR
CABLE TO WING LOCK CYLINDERS
FLAPERON HYDRAULIC ACTUATOR
LOAD RELIEF BUNGEE
DIFFERENTIATING LEVER
CROSSOVER CABLE
FLAPERON POP-UP CYLINDER
WING FOLD LINKAGE
POWER VALVE SHUTTLE
COMBINED HYDRAULIC SYSTEM
TO OPPOSITE WING
CROSSOVER CABLE
LEFT OUTBOARD FLAPERON
LEFT INBOARD FLAPERON
FLAPERON POP UP MECHANISM
2 151577 and subsequent
1 149475 through 151576
FLIGHT HYDRAULIC SYSTEM
Pressure
Return
Up
Flexible Hose

216.152

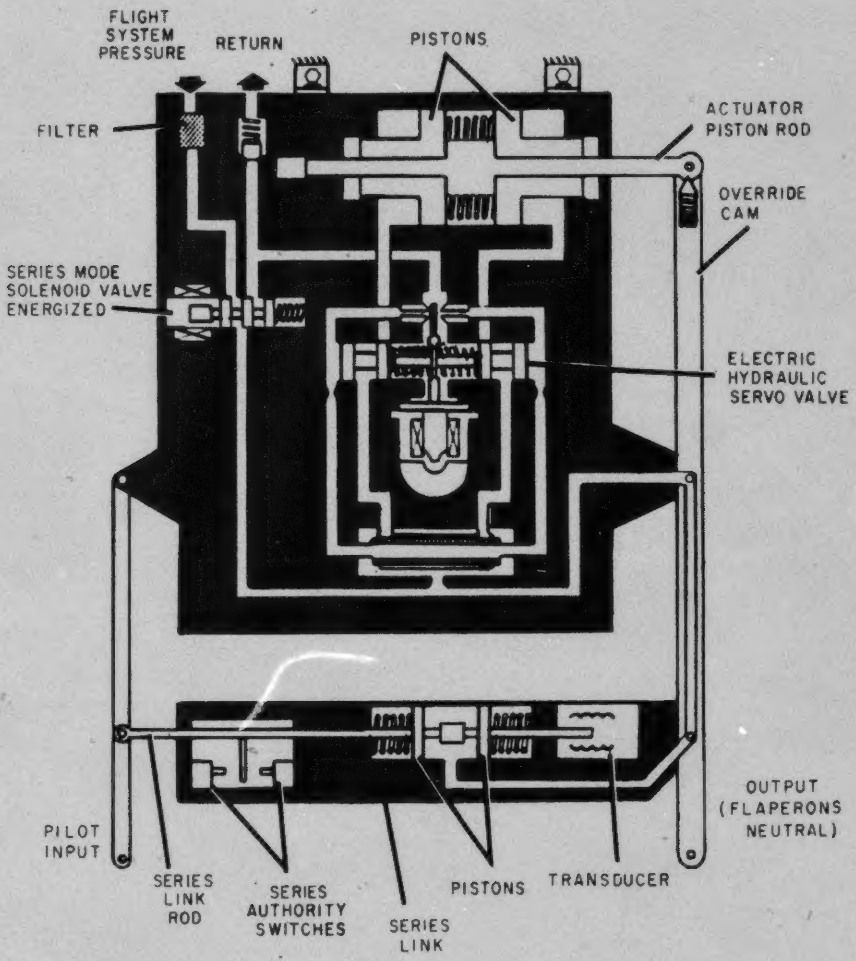
Figure 9-6.—Flaperon control system schematic (A-6).

movement in response to mechanical inputs from the autopilot actuator. The actuator (fig. 9-6) consists of two tandem-mounted power pistons and a power valve shuttle. Mechanical inputs are introduced through the load relief (safety) bungee and the valve input lever to the power valve shuttle portion of the actuator, causing a valve error and porting of hydraulic pressure to the power pistons. As the flaperon moves, mechanical linkage attached to the actuator tends to null this valve error. The power valve shuttle is returned to neutral, and the flaperons remain in the selected position until new mechanical inputs are received from the pilot or the AFCS.

Combination Aileron/Spoiler Deflector System

Several Navy aircraft employ more than one system for lateral control of the aircraft. The A-7, for example, utilizes an aileron and spoiler/deflector arrangement to achieve an increased roll rate about the longitudinal axis. Figure 9-8 illustrates the aileron and spoiler/deflector system schematic diagram for the A-7A.

DESCRIPTION/OPERATION.—In this system, left and right control stick movements are mechanically transmitted to the aileron and


FLIGHT SYSTEM PRESSURE
RETURN
PISTONS
FILTER
ACTUATOR PISTON ROD
OVERRIDE CAM
SERIES MODE SOLENOID VALVE ENERGIZED
ELECTRIC HYDRAULIC SERVO VALVE
OUTPUT (FLAPERONS NEUTRAL)
PILOT INPUT
SERIES LINK ROD
SERIES AUTHORITY SWITCHES
SERIES LINK
PISTONS
TRANSDUCER

216.153

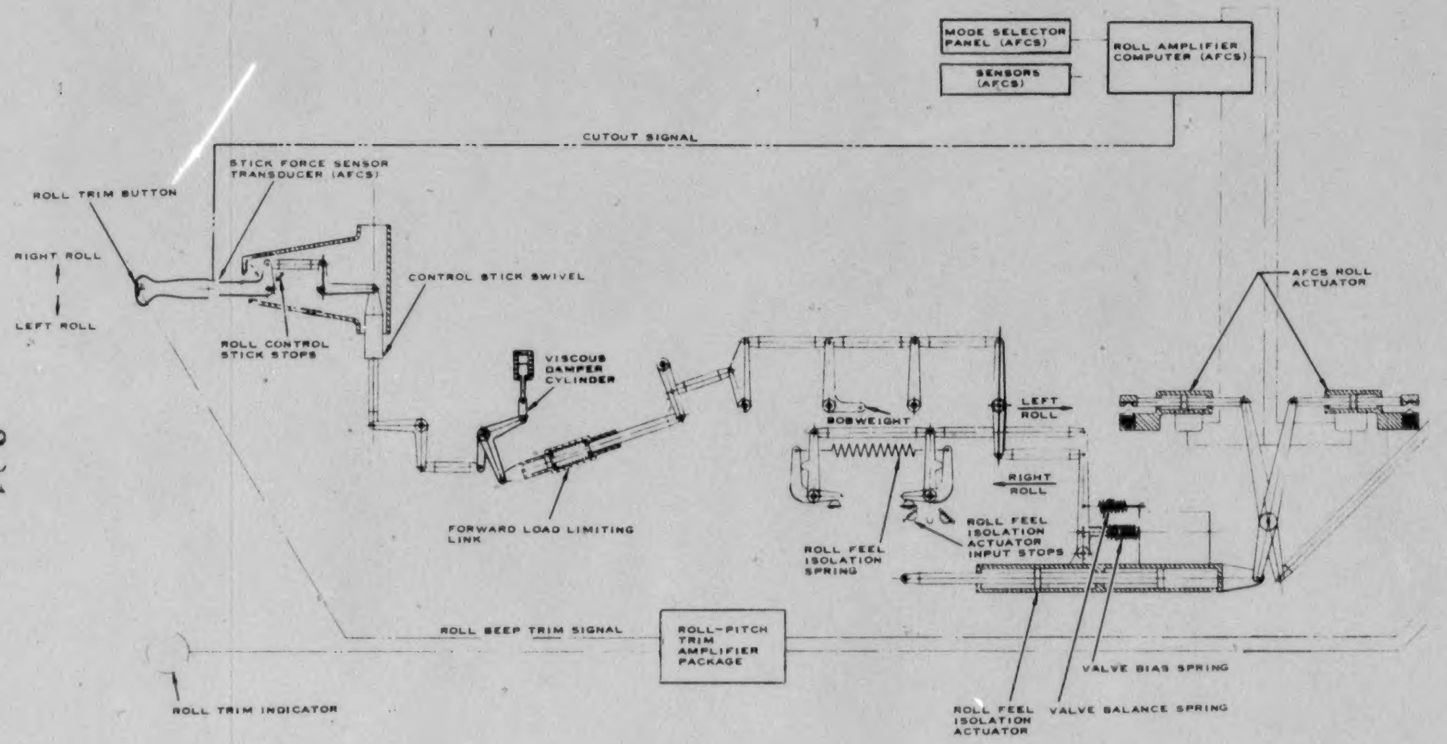
Figure 9-7.—Flaperon autopilot actuator schematic.

spoiler/deflector control linkage. The viscous damper cylinder is connected in the linkage to resist rapid control stick movement, thus preventing overcontrol of the aileron system when the Control Augmentation mode of the Automatic Flight Control System is engaged. The Control Augumentation mode of the AFCS improves lateral and longitudinal stability of the aircraft.

Control linkage and components are protected from excessive loads by the load limiting links located throughout the system. These links have a breakout force so that they normally act as a fixed link. Loads that exceed the breakout force cause the links to extend or retract and absorb the overload.

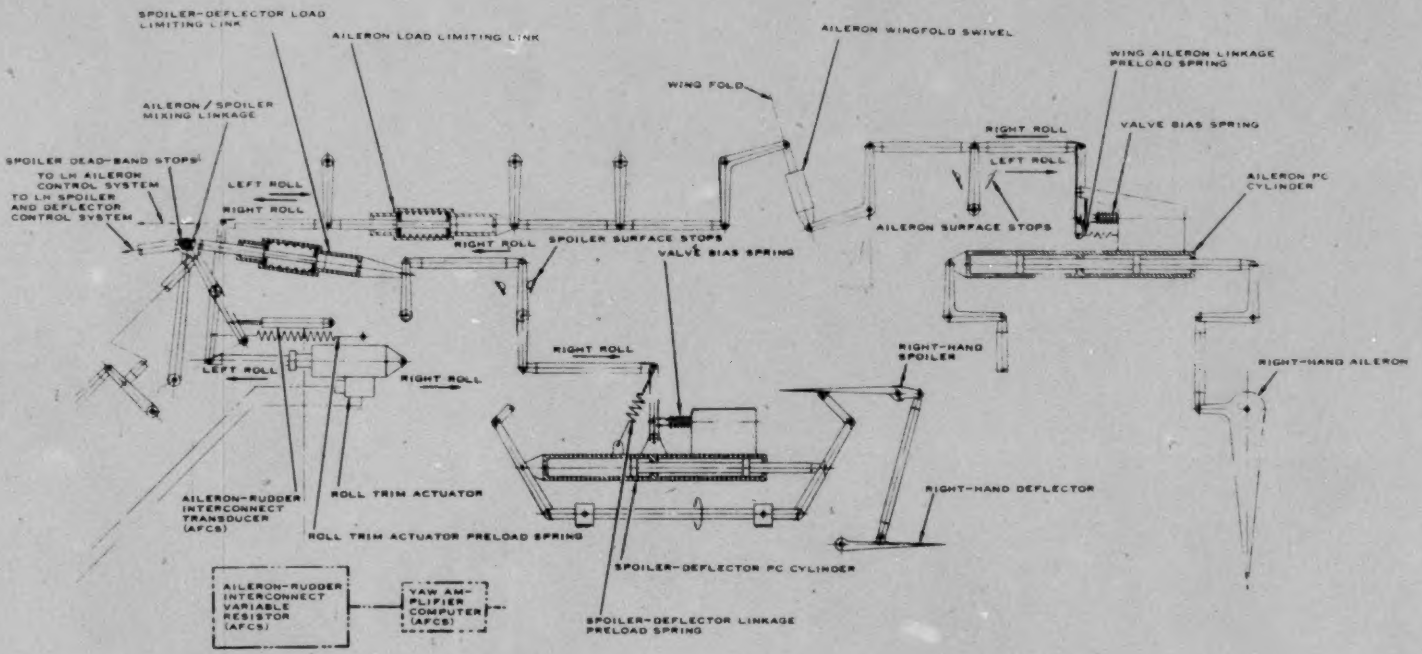
Artificial feel is provided by the mechanical feel spring assembly, which simulates airload resistance at the control stick. When released, the control stick is returned to neutral by the feel spring preload.

The roll feel isolation actuator prevents excessive forces from reaching the control stick. When the control stick is deflected, linkage to


MODE SELECTOR PANEL (AFCS)
SENSORS (AFCS)
ROLL AMPLIFIER COMPUTER (AFCS)
CUTOUT SIGNAL
STICK FORCE SENSOR TRANSDUCER (AFCS)
ROLL TRIM BUTTON
RIGHT ROLL
LEFT ROLL
ROLL CONTROL STICK STOPS
CONTROL STICK SWIVEL
AFCS ROLL ACTUATOR
VISCOUS DAMPER CYLINDER
BOBWEIGHT
LEFT ROLL
RIGHT ROLL
FORWARD LOAD LIMITING LINK
ROLL FEEL ISOLATION SPRING
ROLL FEEL ISOLATION ACTUATOR INPUT STOPS
ROLL BEEP TRIM SIGNAL
ROLL-PITCH TRIM AMPLIFIER PACKAGE
VALVE BIAS SPRING
VALVE BALANCE SPRING
ROLL FEEL ISOLATION ACTUATOR
ROLL TRIM INDICATOR

216.154

Figure 9-8.—Aileron and spoiler/deflector system schematic diagram.


SPOILER-DEFLECTOR LOAD LIMITING LINK
AILERON LOAD LIMITING LINK
AILERON WINGFOLD SWIVEL
WING FOLD
WING AILERON LINKAGE PRELOAD SPRING
AILERON/SPOILER MIXING LINKAGE
RIGHT ROLL
VALVE BIAS SPRING
LEFT ROLL
SPOILER DEAD-BAND STOPS
TO LH AILERON CONTROL SYSTEM
TO LH SPOILER AND DEFLECTOR CONTROL SYSTEM
LEFT ROLL
RIGHT ROLL
AILERON PC CYLINDER
AILERON SURFACE STOPS
RIGHT ROLL
SPOILER SURFACE STOPS
VALVE BIAS SPRING
RIGHT ROLL
RIGHT-HAND SPOILER
LEFT ROLL
RIGHT ROLL
RIGHT-HAND AILERON
AILERON-RUDDER INTERCONNECT TRANSDUCER (AFCS)
ROLL TRIM ACTUATOR
RIGHT-HAND DEFLECTOR
ROLL TRIM ACTUATOR PRELOAD SPRING
SPOILER-DEFLECTOR PC CYLINDER
AILERON-RUDDER INTERCONNECT VARIABLE RESISTOR (AFCS)
YAW AMPLIFIER COMPUTER (AFCS)
SPOILER-DEFLECTOR LINKAGE PRELOAD SPRING

216.154.1

Figure 9-8.—Aileron and spoiler/deflector system schematic diagram—Continued.

the feel isolation actuator servo valve repositions the servo valve slider and directs hydraulic pressure to the actuating pistons. The cylinder housing is connected to the control linkage and moves in the direction corresponding to stick movement. As the housing moves, the servo valve slider is repositioned to neutral, blocking fluid flow to and from the actuator until new inputs are initiated.

The AFCS roll actuator is connected into the control linkage by a scissor link. Normally, this scissor link acts as a simple idler; but when the actuator receives signals from the AFCS, it causes the linkage to act as a variable link. This produces control system inputs completely independent of the control stick.

Output motion from the AFCS linkage is transmitted through control system linkage to the aileron trim and mixing linkage. The mixing linkage directs inputs to both the aileron and spoiler/deflector linkage. Dead-band stops within the mixing linkage allow the ailerons to reach a trailing edge up position of 2 degrees 30 minutes (±15 minutes) before any spoiler/deflector motion is initiated.

The power control cylinders for the ailerons and the spoiler/deflectors are tandem type. Hydraulic pressure is supplied by Power Control No. 1 and Power Control No. 2 hydraulic systems. Half of the servo valve on each cylinder directs PC No. 1 hydraulic pressure to the corresponding half of the PC cylinder, and the other half directs PC No. 2 hydraulic pressure to the other half of the cylinder. If one system fails, the other system is capable of operating the ailerons and spoiler/deflectors.

Input control linkage connected to the servo valve control arm of the PC cylinders positions the valve slider to direct pressure to the actuating pistons, extending or retracting the cylinder housing. As the cylinder housing moves, the servo valve control arm repositions the servo valve slider. When the ailerons' and spoiler/deflectors' position is equal to the demand input, the servo valve slider is again at neutral. Fluid flow is blocked to and from the cylinder until a new control system input is initiated.

The ailerons are located on the wing outer panel trailing edge and, unlike most aircraft, can be fully cycled with the wings folded.

The spoiler/delfector on each wing operates in conjunction with the upward throw of the aileron on that wing. They are located in the left- and right-hand wing center sections, forward of the flaps. The spoiler extends upward into the airstream, disrupts the airflow, and causes decreased lift on that wing. The deflector extends down into the airstream and scoops airflow over the wing surface aft of the spoiler, thus preventing airflow separation in that area.

A stop bolt on the spoiler/deflector bellcrank limits movement of the spoiler to 60 degrees deflection. The deflector is mechanically slaved to the spoiler and can be deflected a maximum of 30 degrees when the spoiler is at 60 degrees. The spoiler deflectors open only with the upward movement of the ailerons and are otherwise closed. The linkage motion lost when the aileron is down is absorbed by the spoiler deflector load limiting link.

LONGITUDINAL CONTROL SYSTEMS

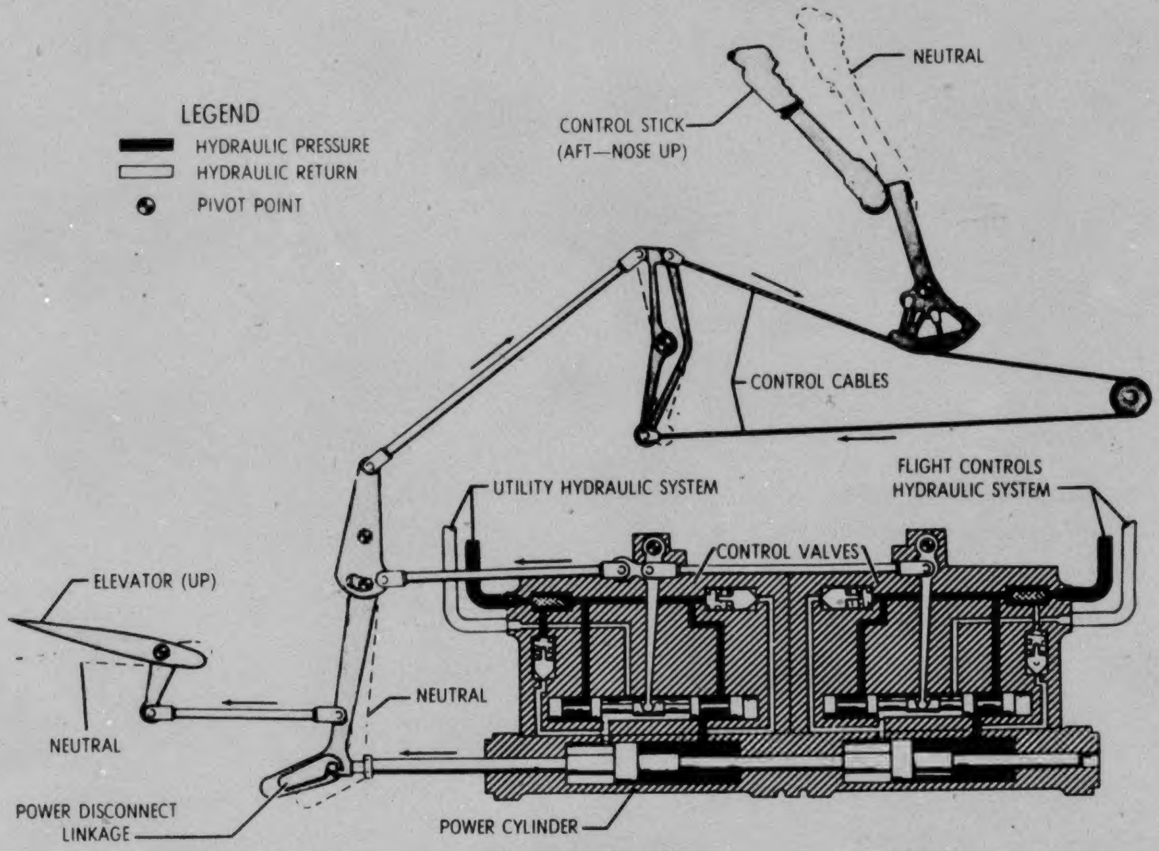
Longitudinal control systems control pitch about the lateral axis of the aircraft. Many aircraft utilize a conventional elevator system for this purpose. However, aircraft that operate in the higher speed ranges usually have a movable horizontal stabilizer. In this section, both types of systems will be discussed.

Elevator Control System

The elevator control system of the A-4 is typical of many conventional elevator systems. It is operated by the control stick in the cockpit and is hydraulically powered by the elevator power mechanism. Figure 9-9 is a functional schematic of this system.

OPERATION.—The operation of the elevator control system is initiated when the control stick is moved fore or aft. When the stick is moved, it actuates the control cables, which move the elevator control bellcrank. The bellcrank transmits the movement to the power mechanism through the control linkage. In turn, the power mechanism actuates a push-pull tube, which deflects the elevators up or down.

The elevator system incorporates a full power irreversible hydraulic system; therefore,


LEGEND
HYDRAULIC PRESSURE
HYDRAULIC RETURN
PIVOT POINT
NEUTRAL
CONTROL STICK
(AFT—NOSE UP)
CONTROL CABLES
UTILITY HYDRAULIC SYSTEM
FLIGHT CONTROLS HYDRAULIC SYSTEM
CONTROL VALVES
ELEVATOR (UP)
NEUTRAL
NEUTRAL
POWER DISCONNECT LINKAGE
POWER CYLINDER

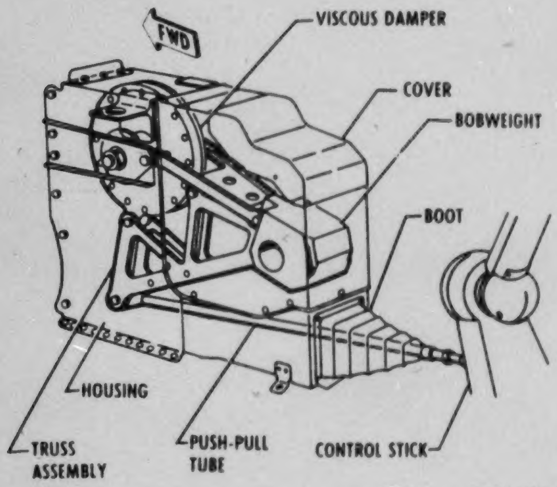
216.155

Figure 9-9.—Elevator control system—functional schematic.

forward and aft bobweights are installed. The bobweights induce a load on the control stick during pitching and vertical accelerations and prevent pilot-induced oscillations through the elevator controls. If the gravity force is increased on the bobweights, the induced load tends to return the control stick to the neutral position. Viscous dampers on the bobweight assemblies retard control stick movement to prevent overcontrol, which could create an overstress condition on the airframe.

The elevator forward bobweight serves to help recenter the control stick when a heavy gravity load pull is applied against the airframe. The forward bobweight and damper assembly (fig. 9-10) is installed in a housing forward of the control stick in the cockpit. The assembly consists of a bobweight, viscous damper, and a push-pull tube. The push-pull tube is the interconnect between the control stick and the bobweight. The damper is located at the pivot point of the bobweight and restricts fast movement of the bobweight.

The aft bobweight and damper assembly (fig. 9-11) works in conjunction with the forward assembly to overcome the heavy pull of gravity and retard the possibility of overcontrol. This assembly is installed in the fuselage forward


FWD
VISCOUS DAMPER
COVER
BOBWEIGHT
BOOT
HOUSING
TRUSS ASSEMBLY
PUSH-PULL TUBE
CONTROL STICK

216.156

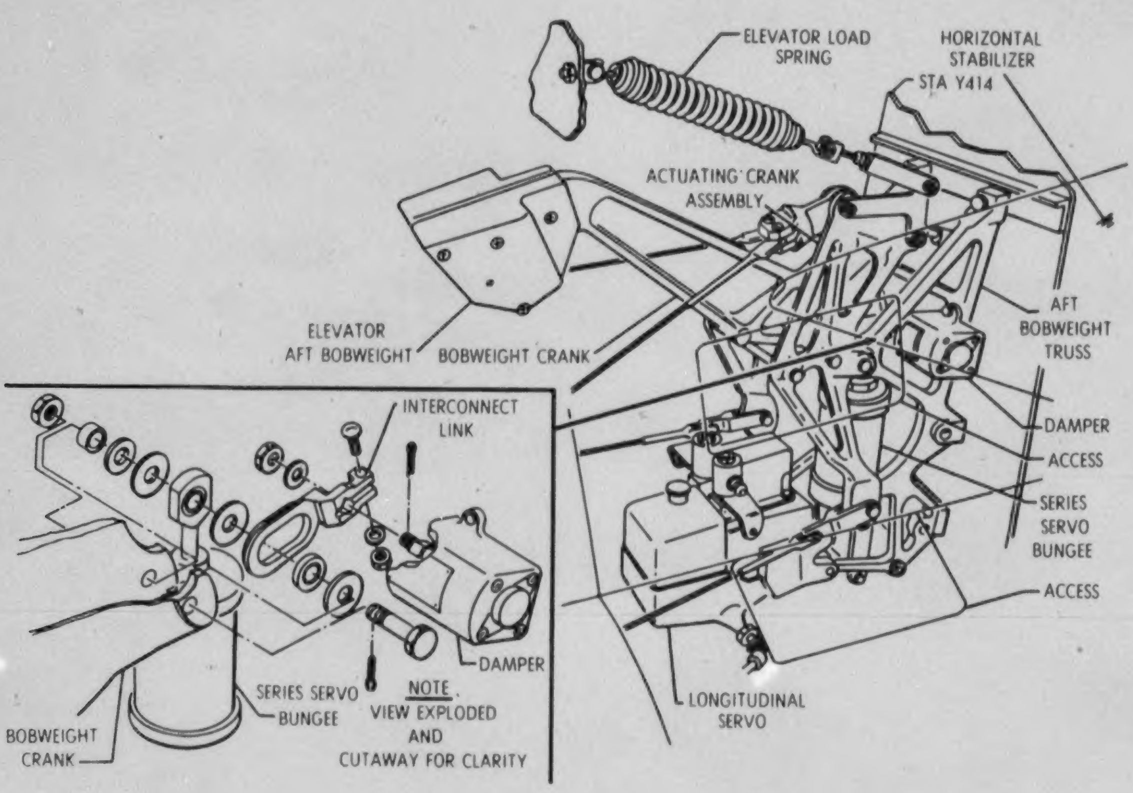
Figure 9-10.—Elevator forward bobweight and damper assembly.

and below the horizontal statibilizer and is connected to the elevator control cables.

The aft assembly consists of a bobweight, viscous damper, and a load spring. The bobweight is connected to the elevator control bellcrank and the damper. The load spring is installed between the elevator control bellcrank and the fin structure to balance the forward and aft bobweights when they are in a static condition (elevators in the neutral position).

The elevator power mechanism (fig. 9-12) changes the mechanical movement of the control stick to hydraulic operation of the elevator. It is installed in the aft section of the aircraft directly below the horizontal stabilizer. As in the aileron power system, the mechanism consists of a hydraulic power cylinder, control valves, linkage, and hydraulic piping.

When the elevator controls are operated, the control valves direct hydraulic pressure to the


ELEVATOR LOAD SPRING
HORIZONTAL STABILIZER
STA Y414
ACTUATING CRANK ASSEMBLY
ELEVATOR AFT BOBWEIGHT
BOBWEIGHT CRANK
AFT BOBWEIGHT TRUSS
DAMPER
ACCESS
SERIES SERVO BUNGEE
ACCESS
LONGITUDINAL SERVO
INTERCONNECT LINK
DAMPER
SERIES SERVO BUNGEE
NOTE
VIEW EXPLODED AND CUTAWAY FOR CLARITY
BOBWEIGHT CRANK

216.157

Figure 9-11.—Elevator aft bobweight and damper assembly.

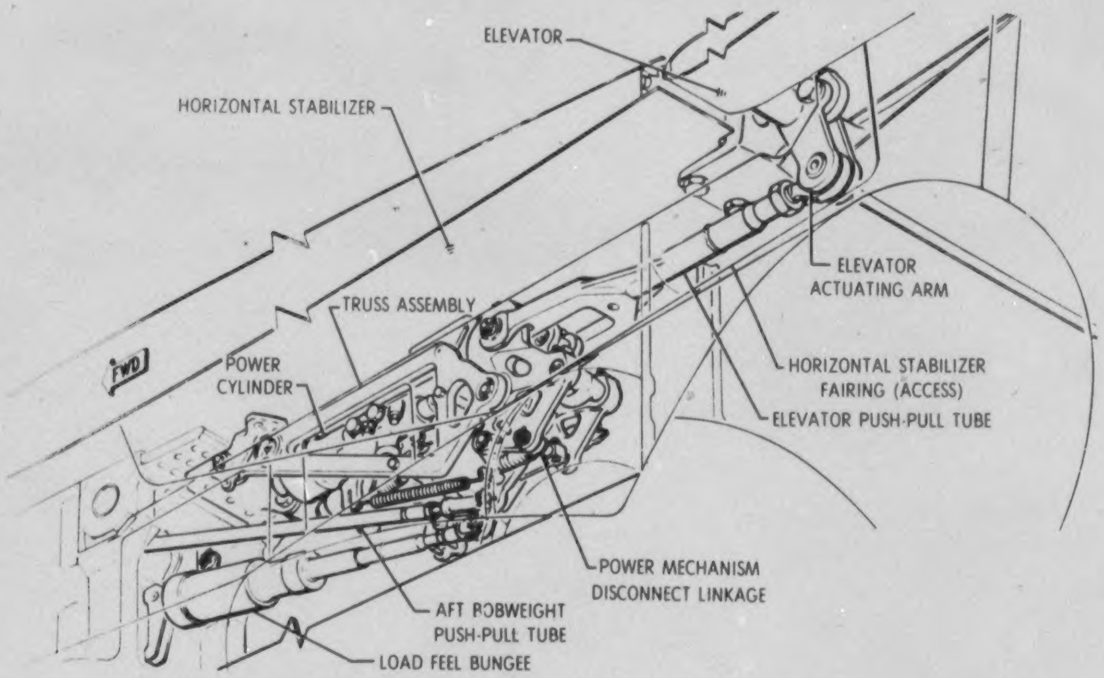
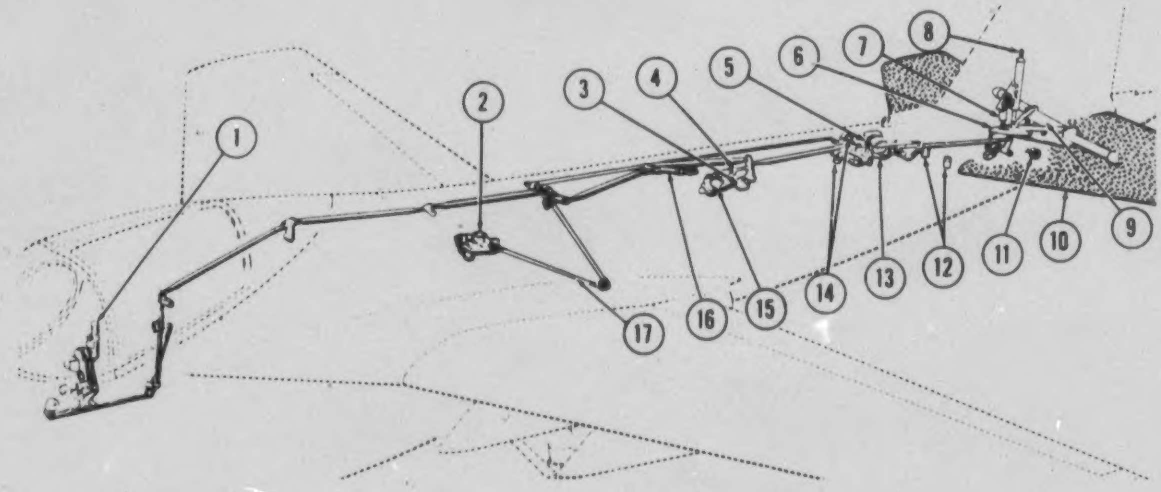

ELEVATOR
HORIZONTAL STABILIZER
TRUSS ASSEMBLY
FWD
POWER CYLINDER
ELEVATOR ACTUATING ARM
HORIZONTAL STABILIZER FAIRING (ACCESS)
ELEVATOR PUSH-PULL TUBE
POWER MECHANISM DISCONNECT LINKAGE
AFT BOBWEIGHT PUSH-PULL TUBE
LOAD FEEL BUNGEE
216.158

Figure 9-12.—Elevator power mechanism—installation.

power cylinder. The hydraulic pressure extends or retracts the cylinder piston to move the push-pull tubes which deflect the elevators. The control valves are two separate valves connected in tandem by linkage. One valve is supplied hydraulic pressure by the utility hydraulic system, and the other valve is supplied hydraulic pressure by the flight controls hydraulic system. The power cylinder has dual hydraulic chambers to work from each control valve. Each hydraulic system simultaneously supplies 3,000-psi hydraulic pressure to the power mechanism. In the event of hydraulic failure of one of the systems, the other supplies sufficient pressure to operate the mechanism, although there is reduced hinge movement. If both hydraulic systems fail, the cylinder can be disconnected by pulling the MAN FLT CONT (manual flight control) handle in the cockpit; then the controls work manually through the linkage of the mechanism to actuate the elevators.

The elevator control linkage consists of two push-pull tubes which interconnect the elevator system. One tube interconnects the elevator control bellcrank with the power mechanism actuating linkage which operates the mechanism control valves. The other tube transmits the movement of the power mechanism cylinder piston to the elevators.

The load feel bungee, shown in figure 9-12, provides an artificial feel to the control stick and acts as a centering device for the elevator system. When the control stick is operated, the spring in the bungee compresses. When the control stick is released, the compressed spring returns the stick to neutral. The bungee also adds a gearing effect between the horizontal stabilizer and the elevators. When the stabilizer is trimmed to give an aircraft noseup condition, the bungee action adds additional noseup elevator. With the stabilizer trimmed nosedown, the bungee action adds additional nosedown



1. Control stick.
2. Flap drive gearbox.
3. Trim transmitter.
4. Artificial feel bungee.
5. Stabilizer shift mechanism.
6. Walking beam.
7. Load relief bungee.
8. Stabilizer actuator.
9. Stabilizer support shaft.
10. Stabilizer.
11. Stabilizer position transducer.
12. Filters.
13. Negative bobweight.
14. Clean and dirty switches.
15. Electrical trim actuator.
16. Static spring.
17. Stabilizer shift mechanism cables.

216.159

Figure 9-13.—Stabilizer control system (A-6).

attitude on the elevator. In both cases, the action is accompanied by a corresponding control stick deflection.

Horizontal Stabilizer Control System

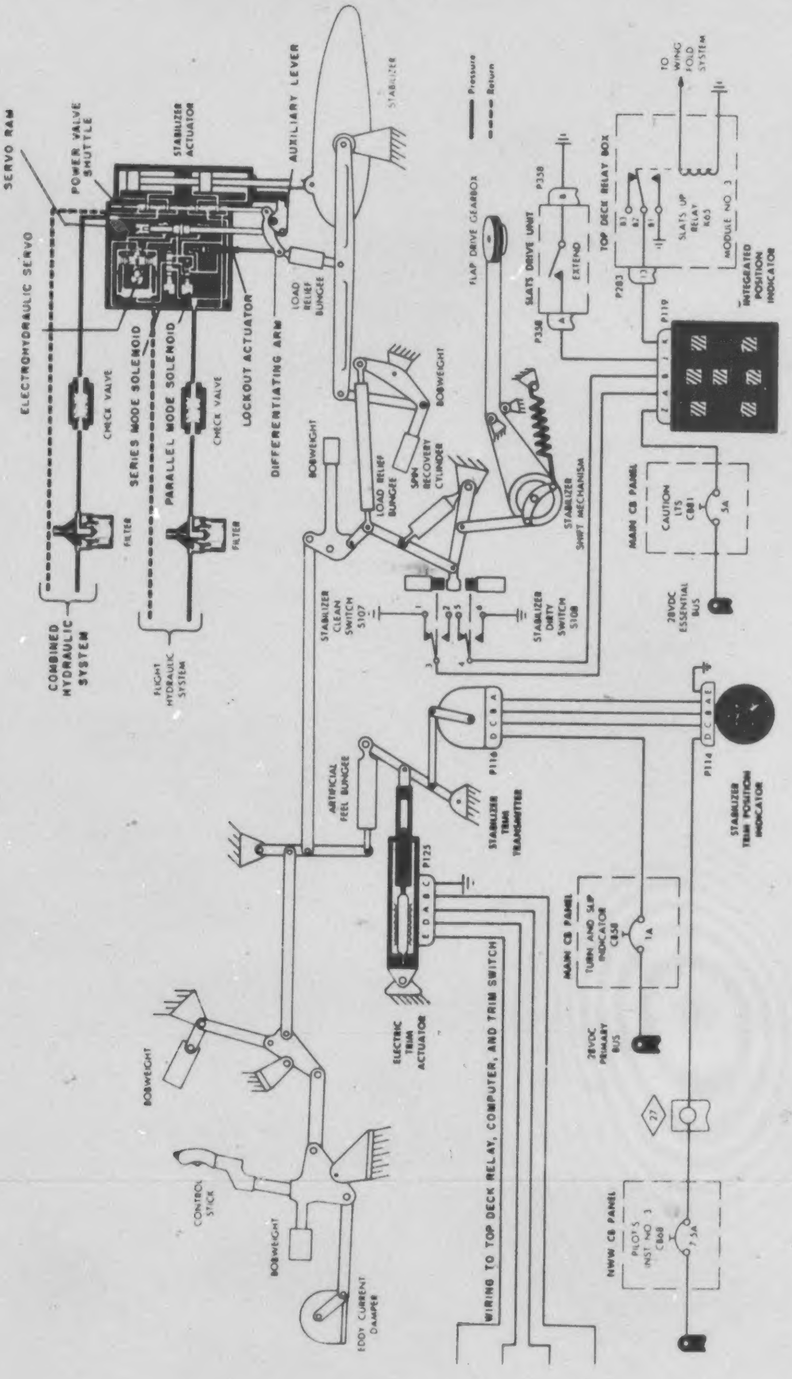
Horizontal stabilizer control systems are given a variety of labels by the various aircraft manufacturers. The A-7, for example, is defined as a Unit Horizontal Tail (UHT) control system. The F-4 is labeled the stabilator control system. Regardless of the variation in nomenclature, these systems function to control the aircraft pitch about its lateral axis.

The horizontal stabilizer control system of the A-6A, described in this section and illustrated in figure 9-13 is representative of the systems used in many present day aircraft.

DESCRIPTION/OPERATION.–The slab type stabilizer responds to fore-and-aft manual inputs at the control stick and to automatic flight control system inputs introduced at the stabilizer actuator.

In the clean configuration, with flaps and slats retracted, stabilizer travel is from 1 1/2 degrees leading edge up to 10 degrees leading edge down. In the dirty configuration, with flaps and slats extended stabilizer travel is increased to 24 degrees leading edge down to provide greater control at slower airspeeds.

Pilot inputs are conveyed by bellcranks and pushrods through the artificial feel components and the trim mechanism to the input linkage of the stabilizer actuator. A trim switch on the control stick grip provides a means of setting stabilizer trim. Stabilizer trim is displayed on the stabilizer trim indicator (fig. 9-14).


SERVO RAM
POWER VALVE SHUTTLE
STABILIZER ACTUATOR
AUXILIARY LEVER
STABILIZER
ELECTROHYDRAULIC SERVO
CHECK VALVE
SERIES MODE SOLENOID
PARALLEL MODE SOLENOID
CHECK VALVE
LOCKOUT ACTUATOR
LOAD RELIEF BUNGEE
DIFFERENTIATING ARM
BOBWEIGHT
FILTER
FILTER
COMBINED HYDRAULIC SYSTEM
FLIGHT HYDRAULIC SYSTEM
LOAD RELIEF BUNGEE
SPIN RECOVERY CYLINDER
BOBWEIGHT
FLAP DRIVE GEARBOX
STABILIZER SHIFT MECHANISM
Pressure
Return
SLATS DRIVE UNIT
EXTEND
P358
P358
TOP DECK RELAY BOX
SLATS UP RELAY K65
MODULE NO 3
P203
P119
INTEGRATED POSITION INDICATOR
TO WING FOLD SYSTEM
STABILIZER CLEAN SWITCH S107
STABILIZER DIRTY SWITCH S108
MAIN CB PANEL
CAUTION LTS CB81
5A
28VDC ESSENTIAL BUS
ARTIFICIAL FEEL BUNGEE
P116
STABILIZER TRIM TRANSMITTER
P114
STABILIZER TRIM POSITION INDICATOR
P125
ELECTRIC TRIM ACTUATOR
MAIN CB PANEL
TURN AND SLIP INDICATOR CB50
1A
28VDC PRIMARY BUS
BOBWEIGHT
CONTROL STICK
BOBWEIGHT
EDDY CURRENT DAMPER
WIRING TO TOP DECK RELAY, COMPUTER, AND TRIM SWITCH
27
NWW CB PANEL
PILOT'S INST NO 3 CB08
7.5A

216.160

Figure 9-14.–Stabilizer control system schematic (A-6).

The position of the stabilizer is shown on the integrated position indicator. When the stabilizer is in the clean configuration, the STAB window of the indicator shows the word CLEAN; when the stabilizer is in the dirty configuration, the window shows a picture of a stabilizer.

The stabilizer actuator (figure 9-14) is a tandem type actuator powered by both flight and combined system pressure. It contains a power valve shuttle, two tandem-mounted power pistons, a servo ram, an electrohydraulic servo valve, a lockout actuator, and parallel and series mode solenoid valves. The actuator can operate in any of three modes: manual, series, or parallel. Reference to figure 9-14 will aid in understanding the three modes of operation as described in the following paragraphs.

Manual Mode.—In this mode, the pilot input alone controls the power valve. Inputs are transmitted through linkage to the mechanical input lever. The auxiliary lever is locked in neutral by the servo ram centering springs, causing the mechanical input lever to rotate about its pivot point, thus moving the power shuttle valve. As the valve shuttle is displaced from neutral, a valve error is established and pressure is ported to the actuating pistons. The pressure moves the pistons and the attached stabilizer in proportion to the input.

A mechanical feedback is transmitted through the differentiating lever, the load relief bungee, and the mechanical input lever back to the power valve shuttle, causing it to return to the neutral position.

For a constant velocity pilot input, a small constant valve error is established and the stabilizer moves at a constant speed. When the pilot input stops, the power shuttle valve is returned to neutral, and the stabilizer stops until new inputs are introduced.

Series Mode.—In this mode, input signals from the automatic flight control system (AFCS) may be used independently or combined with manual inputs to control stabilizer movement. The series mode solenoid valve is energized, porting flight system hydraulic pressure to the electrohydraulic servo valve. Input signals from the AFCS amplifier are applied to the coils of a torque motor in the servo valve, thus regulating flow from the valve to the servo ram.

The servo ram is connected to the auxiliary lever. Movement of the lever moves the mechanical input lever floating pivot point. This causes mechanical input lever rotation about the manual input point and moves the power shuttle valve, again causing a valve error.

A linear transducer, mounted on the servo ram centerline, provides electrical feedback signals to the AFCS. Mechanical feedback is provided by the differentiating lever as in the manual mode.

When operating in the series mode, control surface displacement is not reflected at the control stick.

Parallel Mode.—In this mode, stabilizer movement is controlled by input signals from the AFCS alone. Both series and parallel mode solenoid valves are energized. Flight system pressure is ported to the electrohydraulic servo valve and the mechanical input lockout piston. Fluid pressure stabilizes the lockout piston and holds the mechanical input at neutral. Input signals from the AFCS operate the electrohydraulic servo valve, which drives the power valve shuttle through the servo ram, auxiliary lever, and mechanical input lever.

The transducer mounted on the servo ram provides electrical signal feedback to the AFCS. There is no mechanical feedback, since the mechanical input is locked. Additional electrical signal feedback is provided by a transducer, which is mechanically linked to the stabilizer actuating arm. In the parallel mode, the control stick follows the motion of the stabilizer. Should the pilot desire to override the AFCS, he can overpower the lockout actuator with a stick force of 24 pounds.

Stop bolts are attached to the control stick pedal to limit fore-and-aft stick movement. The eddy current damper dampens out any rapid fore-and-aft stick movement in the same manner as that previously described for the flaperon system.

All joints between the pushrods and bellcranks or idlers contain self-aligning bearings to compensate for any misalignment during operation and airframe deflections in flight that might cause binding.

Artificial feel is provided by the artificial feel bungee. The bungee consists of two springs having different spring constants. The stick force caused by the bungee is proportional to stick displacement. At near neutral, the bungee provides a high stick force that decreases a short distance from neutral and gradually increases with the amount of stick displacement.

The electric trim actuator is mechanically linked to the artificial feel bungee and varies the neutral position of the bungee to provide longitudinal trim of the aircraft. The actuator consists of one high-speed and one low-speed motor, a gearbox, brake, ball detent clutch, and a threaded power screw. Manual control of the actuator is through inputs from the trim switch on the control stick grip. When the stabilizer is in automatic trim, the actuator receives inputs from the AFCS. High speed is used during manual trim and low speed during automatic trim.

The stabilizer shifting mechanism, illustrated in figure 9-14, consists of a shift sector and its linkage plus cable that runs from the flap drive gearbox and the rudder cam shift mechanism. A spin recovery cylinder is also attached to the shifting mechanism and provides an alternate method of shifting the stabilizer and rudder from the clean configuration to the dirty or increased throw configuration.

In normal operation, when flaps are extended, the cable running from a drum on top of the flap drive gearbox to the sector assembly of the shifting mechanism rotates the sector. Linkage connecting the sector assembly and control stick linkage is shifted and, in turn, lengthens control stick travel. Stabilizer down travel is increased to 24 degrees maximum. A cable is also connected from the sector assembly to the rudder cam stop shifting mechanism, which increases rudder travel from 4 to 35 degrees each side of neutral.

The pilot at his option may obtain increased stabilizer and rudder throw by actuation of the spin recovery assist switch, thereby eliminating the necessity of lowering the flaps. This action ports hydraulic pressure through the spin recovery selector valve and its flow regulators and check valve to the spin recovery cylinder, causing it to extend and shift the mechanism in the same manner as provided by the cable action.

The two nonbypass type filters in the system protect the intricate valving mechanisms of the actuator from contamination and are vitally important to proper stabilizer operation. They are checked in accordance with the requirements listed in the maintenance requirements card deck and should not be overlooked when troubleshooting stabilizer system malfunctions.

The stabilizer power package on several Navy aircraft is linked to the Approach Power Compensator System (APC). This system aids the pilot in maintaining optimum angle of attack for approach and landing. An APC potentiometer is mechanically linked to the power package and provides electrical inputs to the APC system to compensate for changes in pitch attitude required during landing approaches. The APC system in turn regulates the throttle position to provide the engine thrust required to establish and maintain the desired angle of attack. The potentiometer provides inputs relative to the position of the horizontal stabilizer.

DIRECTIONAL CONTROL SYSTEMS

Directional control systems provide a means of controlling and/or stabilizing the aircraft about its vertical axis. Most aircraft within the Navy inventory utilize conventional type rudder control systems for this purpose. The A-5 aircraft, due to its high speed and altitude capabilities, has an all-movable vertical stabilizer which functions in much the same manner as a rudder system. Both types of directional control systems are discussed in this section.

Rudder Control System (A-4)

The rudder control system of the A-4 aircraft is operated by the rudder pedals in the cockpit and is powered hydraulically through the power mechanism. In the event of hydraulic power failure, the hydraulic portion of the power system is bypassed and the system is powered mechanically through control cables and linkage. An aerodynamic irreversible hydraulic system is employed in the rudder system, and to facilitate trim, the complete rudder surface is repositioned.

DESCRIPTION/OPERATION.–With the actuation of the rudder pedals, the control cables move a cable sector assembly. The cable sector, through a push-pull tube and linkage, actuates the power mechanism, which deflects the rudder to the left or to the right.

A load feel bungee is connected to the push-pull tube and is compressed when the push-pull tube is actuated. When the pedals are released, the compressed bungee returns the system to the netural position. In the event of hydraulic failure, a slip link allows movement of the control valve linkage to port hydraulic fluid from the actuating cylinder. The cylinder then can be mechanically driven by pilot input during manual operation. In manual operation, surface travels are reduced by the lost-motion effect of the slip link.

The load feed bungee is also the connecting link from the rudder trim actuator to the power mechanism. When the trim actuator is operated, the bungee repositions the power mechanism to deflect the rudder for nose-left and nose-right trim. Figure 9-15 is a functional schematic of the operation of the rudder control system.

The rudder power mechanism is actuated when movement from the cable sector assembly is transmitted through the push-pull tube to the primary control crank. The crank is connected to the load feel bungee, a slip link to the secondary crank, a link and spring to the pedal position transmitter, and a link to the control valve of the actuator assembly. The actuator assembly consists of an electromechanical dual input control valve, a rudder surface position transmitter, and a power cylinder. When the mechanism linkage is actuated, the control valve directs hydrulic pressure from both the utility hydraulic system and the surface control hydraulic system to the power cylinder. The valve directs the hydraulic pressure to two separate chambers in the cylinder. Each chamber has a separate piston which is mounted on a common shaft. The shaft is connected to a push-pull tube which moves the rudder. The actuator assembly normally operates from both hydraulic systems. However, if one system should fail, the other supplies sufficient pressure to operate the rudder with some lost hinge movement. In the event both hydraulic systems fail, the slip link will allow movement of the control valve linkage to port hydraulic fluid from the actuating cylinder.

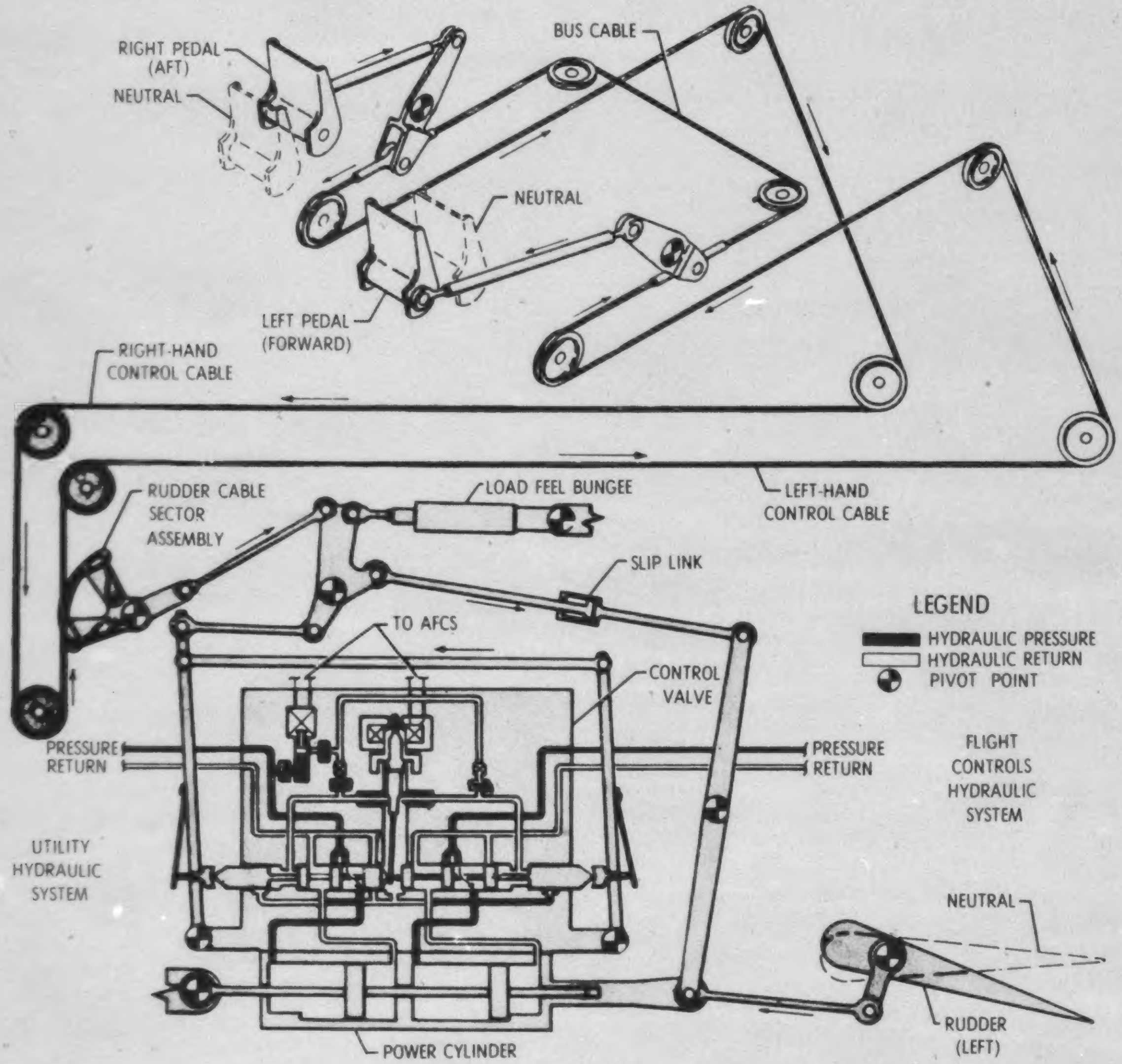
When the automatic flight control system is engaged, the actuator initiates the movement of the rudder system through the electrical impulse received by the control valve from the surface control amplifier. The pedal position transmitter and the rudder surface transmitter function only when the automatic flight control system is engaged.

Vertical Stabilizer Type Directional Control System (A-5)

The A-5 aircraft controls movement about its vertical axis by a mechanically controlled, hydraulically powered, one-piece, all-movable vertical stabilizer. The vertical stabilizer is moved by pilot-induced inputs from the rudder pedals and electrical signal inputs from the yaw augmentation system amplifier. Movement of the vertical stabilizer is also interconnected with lateral control system movement, providing more stable control of the aircraft.

DESCRIPTION.–A mechanical schematic of the control system is provided in figure 9-16. The rudder pedals, through a system of bellcranks and cables, position the surface actuator control valve lever and the control valves to direct hydraulic fluid from the No. 1 and No. 2 hydraulic system to the dual pistons of the surface actuator.

The piston rod of the actuator is attached to the aircraft structure. Two control valves are mounted on the movable actuating cylinder body which is attached to the control surface.


RIGHT PEDAL (AFT)
NEUTRAL
BUS CABLE
NEUTRAL
LEFT PEDAL (FORWARD)
RIGHT-HAND CONTROL CABLE
RUDDER CABLE SECTOR ASSEMBLY
LOAD FEEL BUNGEE
LEFT-HAND CONTROL CABLE
SLIP LINK
LEGEND
HYDRAULIC PRESSURE
HYDRAULIC RETURN
PIVOT POINT
TO AFCS
CONTROL VALVE
PRESSURE
RETURN
PRESSURE
RETURN
FLIGHT CONTROLS HYDRAULIC SYSTEM
UTILITY HYDRAULIC SYSTEM
NEUTRAL
RUDDER (LEFT)
POWER CYLINDER

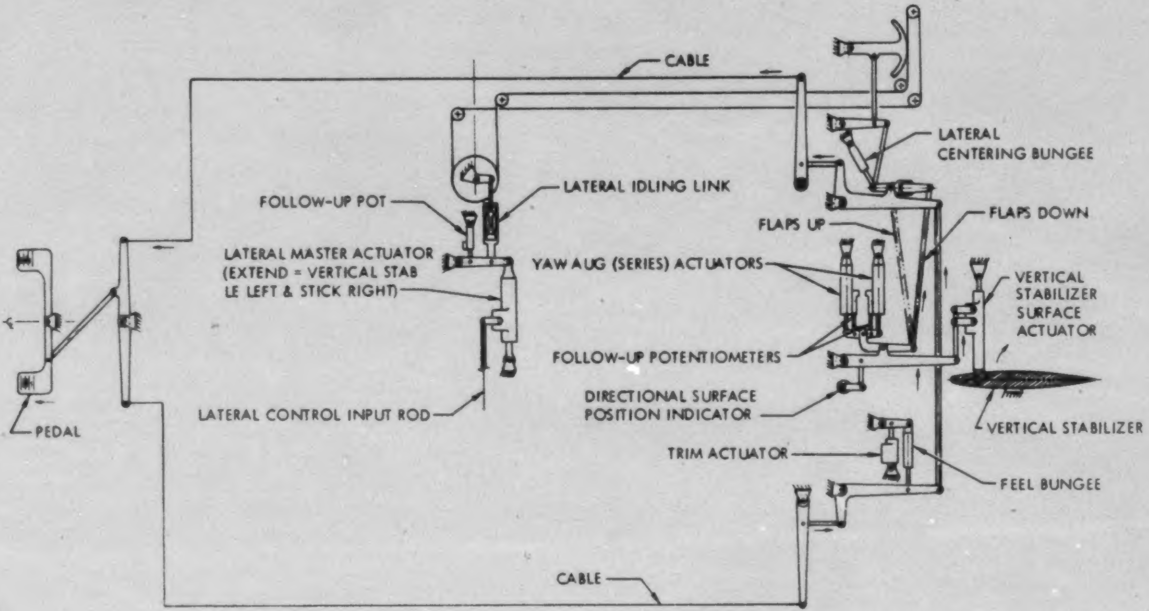
216.161

Figure 9-15.—Rudder control system—functional schematic.

As with the previously discussed power cylinders, the surface moves proportionally to input movement or until the actuator bottoms out at full extend or retract. The surface moves until the mechanical feedback caused by the linkage centers the control valve spools. The surface will stay in the selected position until new inputs are received.

During flaps-up configuration, pedal stops limit travel of the rudder pedals, thus limiting the vertical stabilizer movement to 2 degrees either side of neutral.

With the flaps down and no lateral stick inputs, the vertical stabilizer movement is limited by the stroke of the surface actuator to approximately 8 degrees either side of neutral.


CABLE
LATERAL CENTERING BUNGEE
LATERAL IDLING LINK
FOLLOW-UP POT
FLAPS UP
FLAPS DOWN
LATERAL MASTER ACTUATOR (EXTEND = VERTICAL STAB LE LEFT & STICK RIGHT)
YAW AUG (SERIES) ACTUATORS
VERTICAL STABILIZER SURFACE ACTUATOR
FOLLOW-UP POTENTIOMETERS
DIRECTIONAL SURFACE POSITION INDICATOR
LATERAL CONTROL INPUT ROD
PEDAL
VERTICAL STABILIZER
TRIM ACTUATOR
FEEL BUNGEE
CABLE

216.162

Figure 9-16.—Directional control system mechanical schematic.

The ratio changer interconnect mechanism (fig. 9-17) functions to permit greater movement of the surface when the aircraft is landing or taking off (flaps down).

The lateral directional interconnect mechanism functions automatically to provide movement of the vertical surface during lateral control with the flaps extended.

The forward fuselage mechanism of the vertical stabilizer system includes the rudder pedals, a pedal adjuster actuator, a radius rod, a torque shaft and universal joint assembly, a push-pull rod, a walking beam, and cables.

The intermediate fuselage mechanism consists of fore-and-aft cables and a step-up mechanism.

The aft fuselage group includes cables, bellcranks, push-pull rods, the artificial feel bungee, the yaw trim actuator, the ratio changer assembly, yaw augmentation actuators, mixer bellcranks, and the vertical stabilizer actuator.

Airloads imposed on the stabilizer are not transmitted to the pilot. The artificial feel bungee provides an opposing force or feel when the rudder pedals are moved from neutral. The electromechanical linear type trim actuator provides yaw trimming by repositioning the feel bungee, thus repositioning the neutral position of the vertical stabilizer system.

MECHANICAL OPERATION.—Force applied to either rudder pedal is transmitted by the forward fuselage mechanism to the step-up mechanism and to the ratio changer assembly (fig. 9-17). A swivel rod connects the ratio changer to the mixer bellcrank, which positions the surface actuator control valve rod.

The ratio changer is mechanically actuated by the wing flap system to restrict vertical stabilizer movement when the flaps are in the retracted position.

When the surface actuator valve rod is displaced, the valves are opened, porting reduced hydraulic pressure from the No. 1 and No. 2 hydraulic systems to the piston chambers; and stabilizer deflection results.

The lateral directional interconnect mechanism provides inputs to the vertical

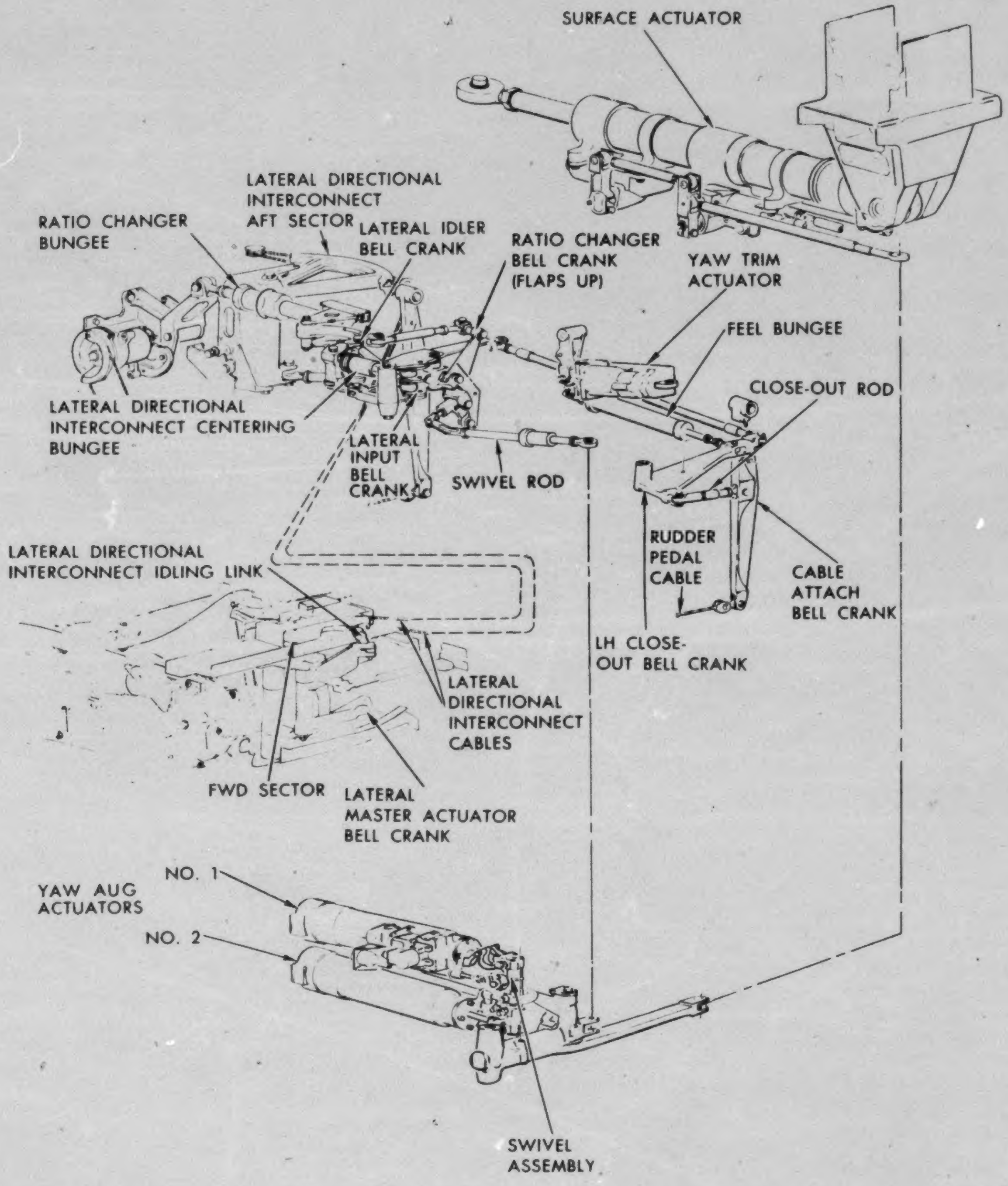

SURFACE ACTUATOR
LATERAL DIRECTIONAL INTERCONNECT AFT SECTOR
RATIO CHANGER BUNGEE
LATERAL IDLER BELL CRANK
RATIO CHANGER BELL CRANK (FLAPS UP)
YAW TRIM ACTUATOR
FEEL BUNGEE
CLOSE-OUT ROD
LATERAL DIRECTIONAL INTERCONNECT CENTERING BUNGEE
LATERAL INPUT BELL CRANK
SWIVEL ROD
RUDDER PEDAL CABLE
CABLE ATTACH BELL CRANK
LATERAL DIRECTIONAL INTERCONNECT IDLING LINK
LH CLOSE-OUT BELL CRANK
LATERAL DIRECTIONAL INTERCONNECT CABLES
FWD SECTOR
LATERAL MASTER ACTUATOR BELL CRANK
YAW AUG ACTUATORS
NO. 1
NO. 2
SWIVEL ASSEMBLY
216.163

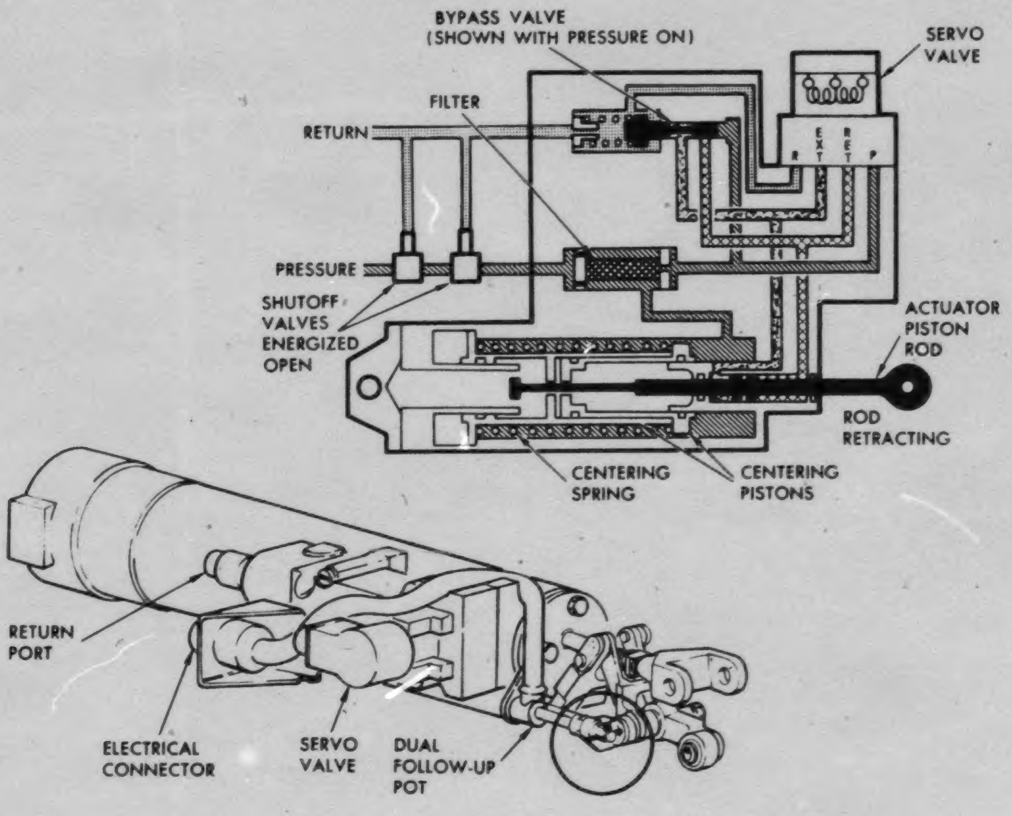
Figure 9-17.–Directional control system unit location.

stabilizer system whenever the lateral control system is operated with the flaps down. A closed cable system (fig. 9-17) interconnects the lateral master actuator linkage with the vertical stabilizer linkage and the flaps to vertical stabilizer ratio changer linkage. When the flaps are up, no motion is induced. When the flaps are down and the spoilers (lateral control) are open to 16 degrees, the vertical stabilizer starts to move. When the spoilers are open to 70 degrees, 4 degrees of stabilizer motion are induced.

The pilot has 10-degree authority with the control pedals and can move the vertical stabilizer up to 10 degrees opposite the position induced by the lateral control system.

During flaps down, the ratio changer linkage is repositioned to provide an input ratio to the vertical stabilizer five times greater than with flaps up. However, since the surface actuators' maximum stroke provides only 8 degrees of surface movement either side of neutral, full pedal travel without lateral stick inputs will be limited by the actuator bottoming out rather than by rudder pedal stops. The pedal stops are effective in the flaps-up configuration and are used during flaps down if lateral stick inputs to the vertical stabilizer of 2 degrees or more are used and the control pedals are moved in the opposite direction, such as stick left and pedal right.

YAW AUGMENTATION OPERATION.–The yaw augmentation system detects yaw, roll, and lateral acceleration (skid), and provides the necessary inputs to the yaw augmentation actuators (figs. 9-17 and 9-18) to


BYPASS VALVE (SHOWN WITH PRESSURE ON)
SERVO VALVE
FILTER
RETURN
R
EXT
RET
P
PRESSURE
SHUTOFF VALVES ENERGIZED OPEN
ACTUATOR PISTON ROD
ROD RETRACTING
CENTERING SPRING
CENTERING PISTONS
RETURN PORT
ELECTRICAL CONNECTOR
SERVO VALVE
DUAL FOLLOW-UP POT

216.164

Figure 9-18.–Yaw augmentation actuator and schematic.

maintain aircraft stability during all flight conditions.

The dual-type system contains two identical and independent channels, each capable of adequate damping and stability augmentation should one channel fail. Each yaw augmentation actuator consists of an electrically controlled servo valve, cylinder body, piston assembly, two centering pistons, centering spring, filter, bypass valve, and a dual followup potentiometer.

The servo valve contains a torque-motor-operated pilot valve, a control spool, and a filter. The forque motor receives electrical inputs from the yaw augmentation amplifier, which causes the reed to deflect from neutral, creating a pressure differential between the end chambers of the control spool. The spool moves in the direction of the lowest pressure and routes hydraulic pressure to the actuator. At the same time, pressure is applied to the bypass valve, forcing it closed against its spring tension and blocking the extend port from the retract port.

In the event one system fails and hydraulic pressure is removed, the bypass valve spring opens the bypass to allow free flow of fluid between the extend and retract ports, preventing a hydraulic lock. The centeirng spring then is free to move the two centering pistons against shoulders of the piston rod until the actuator rod is centered.

This nulls out any surface travel previously provided by the affected actuator, and the remaining actuator can provide approximately 50 percent of the normal surface travel.

As illustrated in figure 9-16 and 9-17, the yaw augmentation actuators are attached to the swivel assembly, which is connected to the mixer bellcrank. Movement supplied by the yaw augmentation actuator does not change the position of the rudder pedals. The mixer bellcrank receives both pilot and yaw augmentation inputs and provides a combined output to the surface actuator servo control valves.

This permits the yaw augmentation system to act independently either by adding or by subtracting from pilot inputs, thereby providing surface deflection as required to stabilize the aircraft.

The dual followup potentiometer located on the actuator (fig. 9-18) is mechanically attached to the actuator rod. As the piston rod retracts or extends, position signals produced by the potentiometer are supplied to the yaw augmentation amplifier.

The roll rate gyro, yaw rate gyro, and lateral accelerometer that provide input information to the yaw augmentation amplifier are maintained by personnel of the AE rating. System malfunctions on flight controls that are supplied inputs from augmentation amplifiers and/or automatic flight control systems will generally require the cooperation of personnel from the AE and AMH ratings to accomplish corrective maintenance and proper operational test.

Electrically controlled shutoff valves are incorporated in the yaw augmentation actuator pressure lines to provide a positive means of disabling the system. They are installed hydraulically in series and electrically in parallel to eliminate the possibility of not being able to shut down the system because of electrical, mechanical, or hydraulic failure.

FLIGHT CONTROL SYSTEMS (F-14)

The F-14 flight control systems represent a markedly different change from the control systems of present naval aircraft. The F-14 flight control systems comprise the rudder, the stabilizer, and the spoiler control systems; the wing surfaces control system; the angle-or-attack system; and the speed brake control system. Because of the complexity and interrelationships of the control systems, only a brief description of the flight control systems is presented. For further information refer to NAVAIR 01-F14-2.

Rudder Control (yaw axis)

Rudder control, which affects the yaw axis, is provided via the rudder pedals. Rudder pedal movement is mechanically transferred to the left and right rudder servocylinders via the rudder feel assembly, the yaw summing network, and a reversing network. These servocylinders, which are normally powered by the flight and combined hydraulic power systems, move the rudders. If both hydraulic systems fail, the rudder servocylinders automatically receive hydraulic power from the backup hydraulic system (flight control backup module). The rudder trim switch on the EXT ENVIRONMENT/THROTTLE control panel enables trimming of the aircraft in yaw. Setting the switch L or R provides a trim left or trim right input respectively to the rudder trim actuator. The actuator then provides rudder movement via the rudder feel assembly, the yaw summing network, the reversing network, and the rudder servocylinders.

Stabilizer Control (pitch/roll axis)

Stabilizer control, which affects both the pitch and roll axis, is provided by forward or aft and/or left or right movement of the control stick grip. Forward or aft movement provides pitch-axis control; left or right movement, roll-axis control. The control stick grip movement is mechanically transferred to the left and right stabilizer servocylinders via the pitch and roll command summing network, the feel assemblies, and the summing network. These servocylinders, which are normally powered by the flight and combined hydraulic power systems move the stabilizers. If both hydraulic systems fail, the stabilizer servocylinders automatically receive hydraulic power from the backup system. The trim switch on the control stick grip enables trimming the aircraft in pitch and roll.

Spoiler Control (lateral axis)

Spoiler is provided via the control stick grip, roll command transducer, roll computer, pitch computer, and eight spoiler actuators (one per spoiler). The spoilers, when used to increase the effect of roll-axis control, can only be controlled when the wings are swept forward of 57°.

Right or left movement of the control stick grip is mechanically transferred to the roll command transducer, which converts the movement to inboard and outboard spoiler roll commands. Because the spoilers are vital for landing, the left and right wing inboard and No. 1 midspoilers are controlled by the roll computer and powered by the combined hydraulic power systems, while the left and right outboard and No. 2 midspoilers are controlled by the pitch computer and powered by the mid-outboard spoiler/high lift backup module. This, then, provides positive spoiler control if either computer or hydraulic power source malfunctions.

Direct Lift Control (dlc)

Direct lift control (dlc) controls the spoilers and horizontal stabilizers to increase aircraft vertical descent rate during landings without changing engine power. Actuating the dlc engage-chaff dispense pushbutton switch on the control stick grip modifies the pitch and roll computer inputs. This modification causes the eight spoiler actuators to position their spoilers 3° up from the 0° positon. The pitch computer also generates the dlc servoactuator command drive at the time of dlc engagement. This command drive, which is applied to the dlc servoactuator, drives the stabilizers to the 6° trailing edge down position from the 0° position. In dlc, the pitch computer and the roll computer permit additional spoiler and stabilizer control via the dlc-maneuver flap-glove vane thumbwheel control on the control stick grip.

Rotating the thumbwheel fully forward, through modified spoiler and dlc command drives, extends the spoilers to the 12° position and drives the stabilizers to the 8° trailing edge down position. Rotating the thumbwheel control fully aft retracts the spoilers to the -4.5° position and drives the stabilizers to 0°. This, in effect, maintains aircraft attitude while changing the vertical descent rate. Direct lift control can be disengaged by momentarily pressing the dlc engage-chaff dispense pushbutton switch or by setting either throttle lever to military power.

Wing Surface Control System

The wing surfaces control system controls the variable-geometry wings to maximize aircraft performance at all speeds and altitudes. The system also provides high lift and drag forces for takeoff and landing, increased lift for loitering, and at supersonic speeds, aerodynamic lift to reduce trim drag.

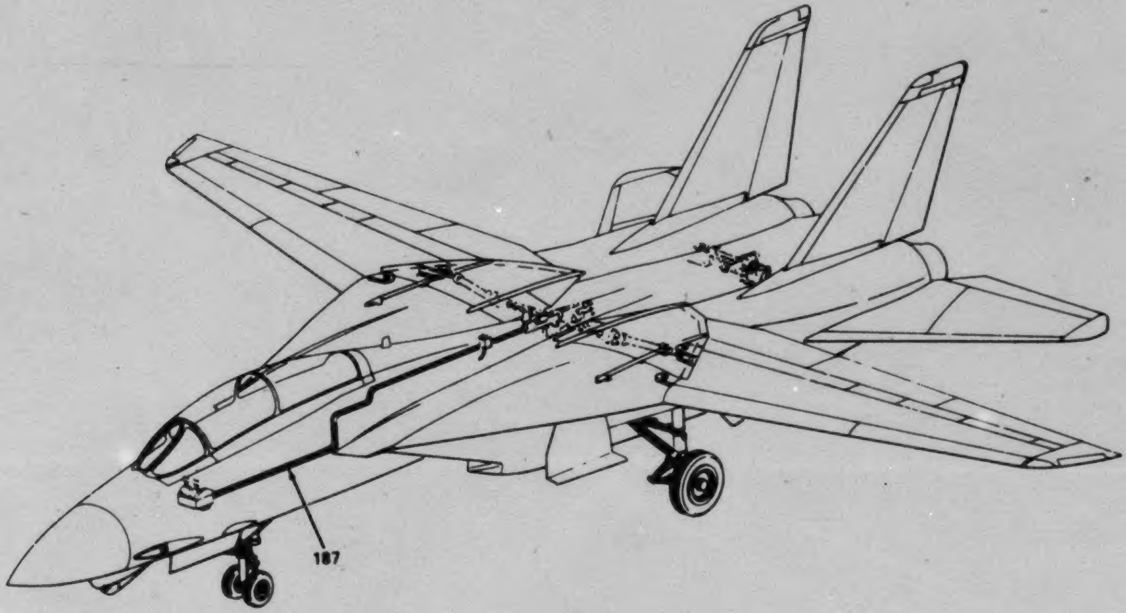


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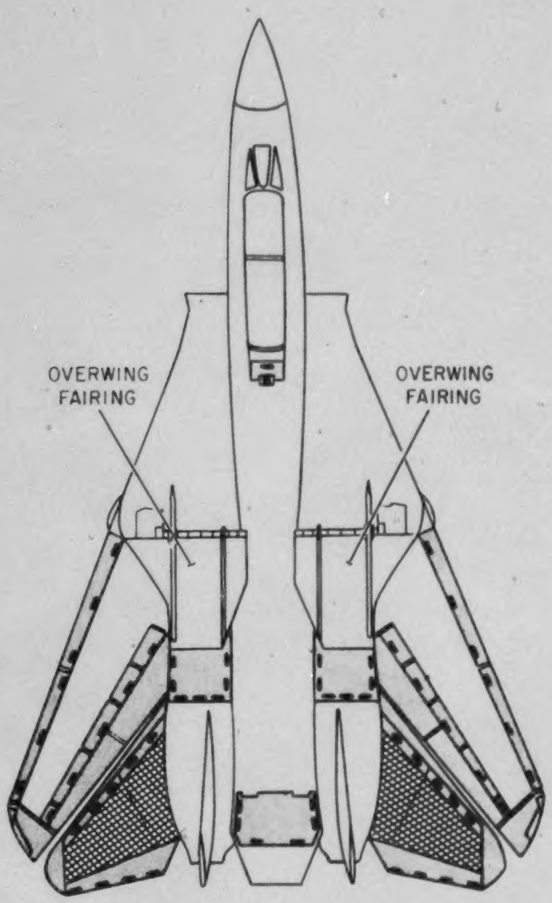
Figure 9-19.–Wing sweep control system (F14).

The wing sweep control (figure 9-19), initiated at the throttle quadrant, provides electronic or mechanical control of a hydromechanical system that sweeps the wings. The wings can be swept from 20° through 68° inflight. On the ground, a wing sweep position of 75° (figure 9-20) is available (via mechanical control) for spotting the aircraft or enabling a wing sweep control self-test.

ELECTRONIC CONTROL.–Wing sweep under electronic control is initiated at the throttle quadrant. Four modes are available–automatic, aft manual, forward manual, or bomb manual. Selection of these modes causes the air data computer to generate wing sweep commands consistent with the aircraft speed, altitude, and configuration of the flaps and slats. The commands are applied via the wing-flap glove-vane controller to the wing sweep control drive servo where they are converted to mechanical rotary force. This force, transferred to the wing sweep/flap and slat control box, causes the wing sweep hydraulic control valve to operate hydraulic motors driven by the flight and combined hydraulic power systems to sweep the wings. The right wing is positioned by the flight hydraulic power system; the left wing, by the combined hydraulic power system. A synchronizing shaft (illustrated in figure 9-19) interconnects the wings to prevent mispositioning. In the event of hydraulic system failure, it provides the driving force for sweeping the wing affected by the failed system.

Wing sweep commands generated by the air data computer are limited by the configuration of the auxiliary flaps, maneuver flaps, and slats. With the auxiliary flaps extended, wing sweep is limited to 21.25°. The maneuver flaps, with or without slats extension, limit wing sweep to 50°. To prevent structural damage to the wings during negative-g conditions, wing sweep is interrupted to prevent wing sweep changes until the negative-g condition no longer exists. In the



216.248
Figure 9-20.—Wing oversweep position—manual control (F14).

automatic mode, the wings are positioned at a rate of 7.5° per second.

MECHANICAL CONTROL.—When wing sweep is under mechanical control, the wing sweep handle positions the wings via the wing sweep/flap and slat control box. Because the minimum wing sweep limiting is not available under mechanical control, the wings can be swept to an adverse position that could cause damage to the wings. Mechanical control is used for emergency wing sweep and wing oversweep.

During emergency wing sweep, the wing sweep handle, mechanically coupled to the wing sweep/flap and slat control box via a cable assembly, positions the wings. The wing sweep can be returned to electronic control by repositioning the wing sweep handle to the stowed position.

Wing oversweep can only be obtained with the aircraft weight on the wheels. Wing oversweep illustrated in figure 9-20, reduces the amount of space required for spotting the aircraft. Additionally, a wing sweep self-test can only be performed while the wings are overswept.

SPIN RECOVERY SYSTEM

The NATOPS Manual for each naval aircraft provides procedures to be utilized in regaining control of the aircraft after a spin has developed. In some cases these procedures are similar for the particular type of spin being encountered. It is imperative in each case of suspected spin that the pilot verify that he is actually in a spin and not experiencing post-stall gyrations. Corrective spin recovery action during post-stall gyrations can force the aircraft into a spin.

In the A-6 aircraft, a spin recovery system provides for increasing the horizontal stabilizer and rudder control surface throws to accommodate recovery from all spins in 1 to 1 1/2 turns.

As was briefly mentioned in the section on the stabilizer control system for the A-6, the increased throws are available when the aircraft is in a dirty configuration (flaps down) and can be selected with the aircraft in a clean configuration by the pilot-controlled ASSIST SPIN RECOV switch.

Figures 9-13 and 9-14 illustrate the shifting mechanism and associated actuating cylinder used to provide the increased throws.

Operation

When the flaps are up, the stabilizer shift mechanism displaces linkage connecting the control stock to the stabilizer and restricts movement of the stabilizer to 1 1/2 degrees leading edge up to 10 degrees leading edge down. At the same time, rudder cam stop linkage, or as it is more commonly known, the rudder shift mechanism, is displaced against the tension of the shift return spring. Cam stops are rotated to the minimum position, restricting rudder movement to 4 degrees each side of neutral.

The ASSIST SPIN RECOV switch, when placed in ASSIST, actuates the spin recovery selector valve, directing combined hydraulic system pressure to the spin recovery cylinder extend port. Cylinder extension shifts the stabilizer mechanism and the rudder mechanism to the flaps down configuration (the flaps stay up), permitting stabilizer movement of 1 1/2 degrees leading edge up and up to 24 degrees leading edge down. Rudder movement is increased to 35 degrees each side of neutral.

In an erect spin situation, the pilot applies full rudder deflection in the opposite direction of spin based on turn needle indications. The control stick is held full aft and neutral laterally. Simultaneously, or as soon as possible, momentary increased throws are selected with the ASSIST SPIN RECOV switch. When rotation ceases, the rudder is immediately neutralized and the control stick is moved forward to at least the neutral position.

If the controls are not neutralized as soon as spin rotation has ceased, the aircraft will experience violent lateral snaps which will cause the aircraft to assume a steeper nosedown position and require more altitude for recovery to level flight.

After the aircraft has returned to level flight and at or below 300 knots indicated airspeed, the assist spin recovery switch is returned to the OFF or cruise control throw position, allowing the rudder and stabilizer shift mechanism to return to the clean configuration.

Inverted spins call for basically the same procedures and maneuvers except that the control stick is initially held full forward and neutral laterally.

The procedures for recovery from flat and precision spins as well as from erect and inverted will vary for each type of aircraft. The additional throw feature of the A-6 merely provides for a more rapid recovery than would be available with the limited throws available in the clean configuration.

BACKUP FLIGHT CONTROL SYSTEM

Despite the dual system design requirement for flight control systems, a complete hydraulic system failure is possible. System failure could be a result of component or plumbing failure or as a result of enemy-inflicted damage. Backup flight control systems such as that utilized on the A-6 aircraft provide for an additional measure of flight control safety.

The system is activated whenever a partial or complete hydraulic system failure occurs and provides the capability of recovery from unusual attitudes, basic navigation, and under optimum conditions, field landings.

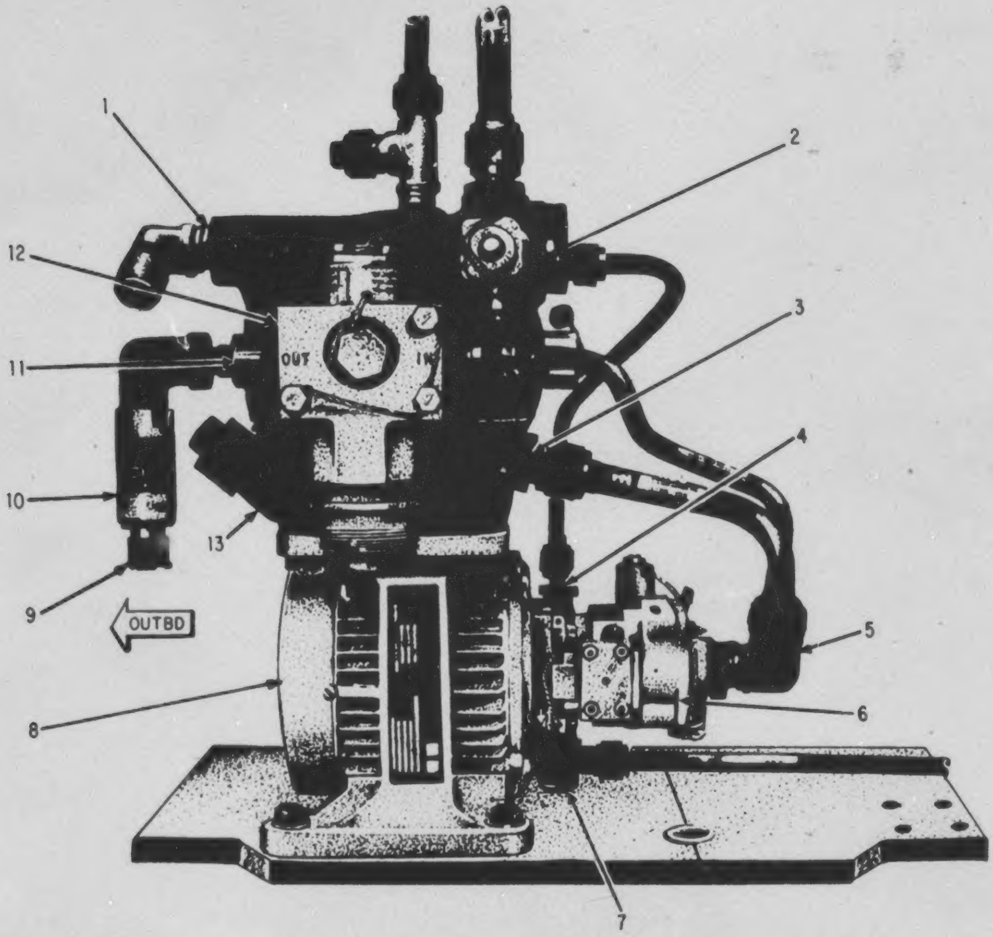
Description/Operation

The complete backup flight control system, illustrated in figure 9-21, is mounted on protective armor plating measuring only 8 by 16 inches and located in proximity to the rudder and stabilizer power packages. Operation of the system is controlled by flight and combined hydraulic system pressure line switches.

The two switches in the pressure lines to the backup flight system are wired normally closed at zero pressure, and the backup pump outlet pressure switch is wired to normally open at zero pressure. The switches actuate at 900 to 1,100 psi on rising pressure and 700 to 900 psi on decreasing pressure. Closing of the combined or flight system pressure switches energizes the backup system motor pump. Closing of the outlet pressure switch lights the backup hydraulic system indicator light on the annunciator panel in the cockpit.

When pressure in the flight and/or combined hydraulic system decreases to 700 to 900 psi, the system is automatically activated. The system isolates a portion of the combined system in the tail of the aircraft by means of check valves in the pressure lines and a shutoff valve in the return line. When the shutoff valve closes, a full charge of fluid is stored in the backup system reservoir for operation of the system.

The reservoir is mounted on top of the motor-pump assembly. It has a capacity of 0.84 quart. The return system shutoff valve is an integral part of the reservoir end flange and is



1. Rudder return port.
2. Case drain (reservoir).
3. Suction port.
4. Case drain (pump).
5. Suction and pressure ports.
6. Pump.
7. Seal drain port.
8. Motor.
9. Electrical receptacle.
10. Pressure switch.
11. Check valve.
12. Filter assembly.
13. Reservoir assembly.

216.165

Figure 9-21.—Backup flight control hydraulic system (fwd view).

located inside the reservoir pressurizing spring. The soft-seated poppet type shutoff valve is held open when the reservoir is at the full position. When pressure drops and the reservoir piston moves approximately 3/16 inch away from the full position, the spring-loaded valve closes and prevents flow out of the reservoir. The shutoff valve also acts independently as a relief valve to relieve reservoir pressure above 95 psi.

Return fluid flow from the rudder and stabilizer actuators fills the backup system reservoir. When the reservoir approaches the full position, it mechanically opens a shutoff valve, allowing return flow to go to the combined system reservoir. In normal flight, the 40-psi return system pressure is sufficient to maintain the backup reservoir piston at the full position and the shutoff valve fully open against its spring pressure.

If return system pressure drops below the reservoir pressurizing spring pressure of 15 psi, the reservoir piston moves and displaces fluid through the shutoff valve. As the piston moves, the shutoff valve closes and is fully closed in 3/16 inch of piston movement.

The shutoff valve may open momentarily during backup system operation to discharge excess fluid volume as a result of unequal stabilizer instroke and outstroke volume or thermal expansion of the fluid. The shutoff valve also opens when the flow rate exceeds the flow capacity of the backup pump. The latter condition could occur when the flight system is operating normally and high rate inputs are applied to the actuators.

Pressure line isolation is accomplished by the use of check valves. To ensure against backup system leakage to a failed combined system, a soft-seat check valve is installed upstream of the standard metal-seat check valve in the combined system pressure line.

A three-position backup system hydraulic test switch is located in the cockpit. The central spring-loaded OFF position provides automatic function in flight. The momentary hold positions, COMBINED and FLIGHT, are used for ground test of the system when the aircraft is on external electrical power. Selection of either position will energize the motor pump when aircraft pressure is less than 700 to 900 psi.

The system is protected from contamination by a cartridge-type filter element housed within the reservoir head and a pressure line filter.

Since the backup motor pump is energized when either or both primary systems fail, the following three operational conditions can exist.

1. With the backup and flight system operating, normal flight control is available. The backup system performs as an isolated system with the return shutoff valve closed. Since the variable displacement backup motor pump has a maximum rated output of 3.0 gpm at 1,000-psi output pressure to zero gmp at cutoff pressure (3,000-3,200), it cannot match the high rate capacity of the flight system. Backup motor pump pressure will drop to zero when demand exceeds 3.0 gpm, causing the cockpit indicator light to go out. When pressure increases to 900 to 1,000 psi, the light will come on again indicating backup system operation.

2. With the backup system and combined system operating, normal flight control is available. The backup system is not isolated, as normal combined system pressure exists within pressure and return lines. The return shutoff valve remains open. Combined system pumps maintain high pressure at the rudder and stabilizer actuators; therefore, flow demand on the backup pump is not excessive at high rates, and the cockpit indicator light should remain on, indicating backup system operation.

3. When the flight and combined systems fail, the backup flight control system performs as an isolated system. Surface rates available at the rudder and stabilizers are reduced by the limited output of the backup pump, and there is no flaperon actuator control. The cockpit indicator will flicker out if the pilot applies inputs to the controls that exceed the capacity of the pump. The cockpit RUDDER THROW light will also be illuminated to indicate that approximately 33 percent of normal rudder throw is available for aircraft control.

PRIMARY FLIGHT CONTROL SYSTEM MAINTENANCE

Maintenance of lateral, longitudinal, and directional control surface power actuators is generally beyond the capability of intermediate and organizational maintenance level activities. Removal of hydraulic components and associated linkages on the power actuators will destroy critical adjustments. Readjustment requires special tooling, jigs, and other equipment available only at depot level maintenance facilities. When a power mechanism has been isolated as the cause for flight system malfunction, it is removed and forwarded with the accompanying paperwork to the supply activity for disposition. Power actuators for which a Disassembly and Inspection Report (DIR) has been requested will be forwarded to the overhaul or investigating activity in accordance with disposition instructions received from competent authority.

MALFUNCTION OF FLIGHT CONTROLS

There have been numerous cases reported in which, subsequent to flight, pilots have found flight controls jammed while the aircraft was on the ground. Due to the fact that the controls were freed by excessive pressure before an inspection could be made, the causes for the jammed condition could not be found. Consequently, no positive corrective action was taken before the aircraft were released for flight. In some cases, accidents occurred on such aircraft shortly thereafter.

The NAVAIRSYSCOM policy concerning the inspection and reporting of flight controls malfunctions is clearly set forth in NAVAIR Instruction 3750.2 (Series). This instruction requires that the following actions be taken when any flight control is found jammed on the ground.

1. All pilots finding the controls jammed or restricted while the aircraft is on the ground shall make no effort to free the controls by force. A light pressure should be held against the controls and an immediate inspection called for.

2. On aircraft using hydraulic power in the flight control systems, and where separate ground connections are teed into the hydraulic system, external power must be applied to maintain system pressure prior to shutting down the engine(s).

3. With power on the aircraft and light pressure on the controls against the restriction, a visual inspection only shall be made. All personnel should keep all parts of their body clear of the control mechanisms and surfaces while performing the visual inspection with power on the system.

CAUTION: Do not remove any structural access door or panel which the Maintenance Instructions Manual states shall be installed during power operation of the system.

4. If the fault is not readily apparent on visual examination, all hydraulic power should be reduced to zero and the trouble isolated by systematic disconnection of controls. The inspection shall be conducted in the presence of qualified personnel.

In cases where aircraft have safely returned from a flight during which a controls discrepancy was experienced, a thorough investigation for definite causes shall be made before further flight. All parts of the affected control system shall be inspected for proper rigging, clearances, and potential causes for interferences. All sealed units which are suspected must be replaced. Primary cause factors that should not be overlooked include maneuvers that have exceeded the operational design of the control systems (overstress), hydraulic system contamination, corrosion, distorted or disconnected linkage, inadequate lubrication, and external contamination in the form of preservative compounds, such as grease combined with dirt and dust. An increasing number of flight control system malfunctions are related to system contamination, and this ever important aspect of hydraulic system maintenance should be given the attention it deserves. Checking of system filters and contamination inspection of suspected systems are within the capability of organizational activities. If a system is found to be contaminated, the source of contamination must be eliminated, the system cleaned by recycling or flushing in accordance with instructions provided in the appropriate Maintenance Instructions Manual, and contaminated components replaced as necessary to restore proper system operation.

Disposition instructions for removed hydraulic components vary with the production status of the aircraft model. In any event, diligent care must be taken to retain the component in the as-is condition, with no change in adjustment, disassembly, or cleaning. If the component has slides or pistons that are jammed, no attempt to free them should be made.

TROUBLE ANALYSIS

Trouble analysis of the flight control systems requires the same systematic approach as any other hydraulic system. In many instances, malfunctions are written off with corrective actions on the Maintenance Action Form reading, "Could not duplicate," or "Replaced suspected component," etc., with the next flight resulting in a repeat discrepancy or possibly a loss of the aircraft. Thoroughness in determining the cause of malfunction cannot be overemphasized.

Trouble analysis of the flight controls will require complete cooperation with other work centers that may be involved in the complete and thorough operational checkout. Most flight control systems are provided electrical inputs as well as mechanical inputs from autopilot, automatic flight control systems, or stabilizing augmentation systems; and these inputs occasionally cause erratic and/or misleading aircraft flight characteristics. These characteristics can be misinterpreted, and the resultant writeup in the aircraft discrepancy portion of the A/C flight record book may be vague or misleading.

In cases of this nature, the maintenance crew assigned to troubleshoot the malfunctioning system should question the pilot who experienced the malfunction in an attempt to gain further insight regarding the vague discrepancy rather than waste valuable manhours.

Isolating the mechanical and hydraulic portion of the flight control system from systems that provide automatic inputs will serve to pinpoint the actual problem area.

On systems that are maintained by personnel of more than one rating, maintenance/production control should assign the discrepancy to the logical work center and issue a duplicate job control number assignment to the other work centers for assistance. Working together these work centers can reach a logical and conclusive reason for the system malfunction.

The Maintenance Instructions Manual provides troubleshooting/trouble analysis aids and appropriate schematics to allow systematic checking out of the system and associated components. In some MIMs these aids are general in nature and limited to the more common causes of failure. Several MIMs combine the operational checkout procedure with trouble analysis aids. Steps of the checkout procedure are performed in rigid sequence, and any discrepancy must be corrected before proceeding to the next step.

In all cases, a thorough knowledge of the system involved and consistent use of the mechanical and hydraulic schematics provided in the MIM will expedite the trouble analysis process. Excessive time required for troubleshooting should be documented on a separate VIDS/MAF. This will separate the actual repair time from troubleshooting time, thus providing more accurate input information to the Maintenance Data Reporting System.

When the malfunction has been determined and corrected, the complete system should be operationally tested in all modes of operation to verify system integrity. Quality assurance inspection during repair progression, testing, and of the end product is a must.

In all cases, rigid conformance to instructions and cautions provided in the applicable MIM and any other outstanding maintenance directive involving the type of aircraft being maintained must be demanded. Test flight requirements, when prescribed in the applicable Periodic Maintenance Information Cards, are mandatory. The test flight pilot is briefed by a qualified quality assurance representative regarding the nature of the discrepancy and corrective action taken.

ALIGNMENT AND OPERATIONAL CHECKS

Procedures for rigging the flight control systems vary with each type of aircraft. A list of tools and special equipment, preparatory considerations, and step-by-step instructions for

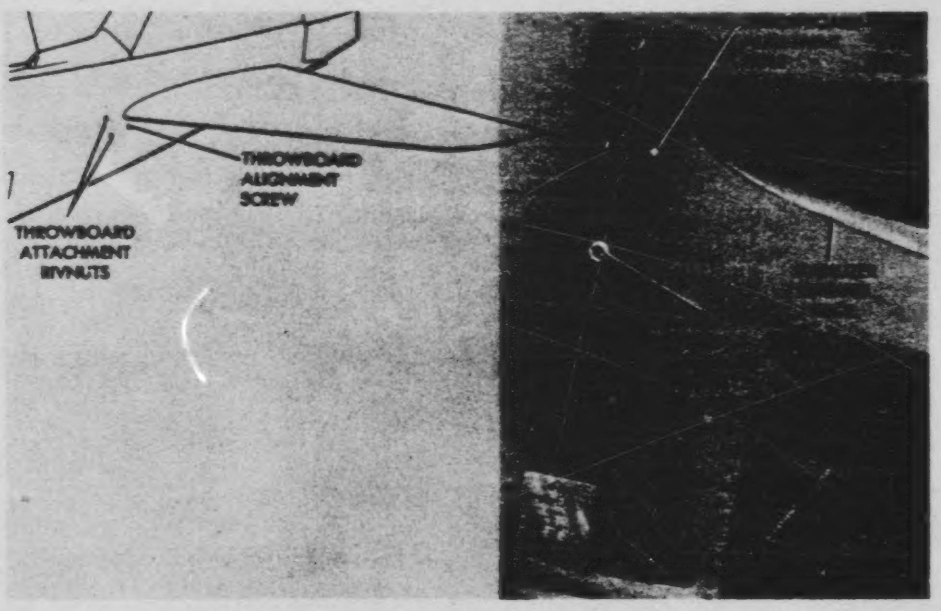


Figure 9-22.—Stabilizer throwboard installation (A-6).

rigging a section or the complete system is provided in the applicable MIM.

On some aircraft, the system to be rigged is divided into a series of sections, such as the control stick, control mechanism, power control actuator, cables, etc. If only that section of the system has been affected, it may not be necessary to rig the complete system.

Pushrods, bellcranks, and idlers are installed, so that end play is eliminated, but should be free to rotate without binding. Cables should be inspected for corrosion, broken strands, and proper tension. Correct cable tension is necessary in order to obtain proper response of the control surface. Low cable tension may cause sluggishness, free play, flutter of the surface, or insufficient travel of the control surface. Excessively high cable tension will cause increased system friction and may result in damage to pulleys, bellcranks, or the cable itself.

A variety of alignment fixtures is available for checking control surface throws, neutralizing the control stick and rudder pedals, and pinning the associated linkage in neutral as required during the alignment process. Installation and removal of alignment pins should not require excessive force. Slight pressure is permissible due to system tolerances and temperature effects on the linkages.

Figure 9-22 illustrates the throwboard utilized to check travel of the horizontal stabilizer of the A-6 aircraft. The throwboard is held in place by two wingnut attachment screws. Prior to tightening these screws, the throwboard is aligned so that the alignment hole at the zero degree mark is over the alignment screw in the aircraft fuselage.

Control surface throws may be measured in degrees, degrees and minutes, or inches and fractions thereof. Figure 9-23 provides an example of the aileron throw indication for the A-7 aircraft in degrees (°) and minutes ('). The protractor scale is calibrated in 30-minute increments. The indicator reads 3 degrees 40 minutes obtained as follows:

1. Read 3 degrees 30 minutes as indicated on the protractor scale.

2. Since the indication mark does not fall directly on the calibrated mark of the protractor scale, look for the closest alignment of indicator and protractor calibrated marks in the direction of indicator travel. Read the value from the 0 minute mark on the indicator to the closest alignment, which in this example is 10 minutes.

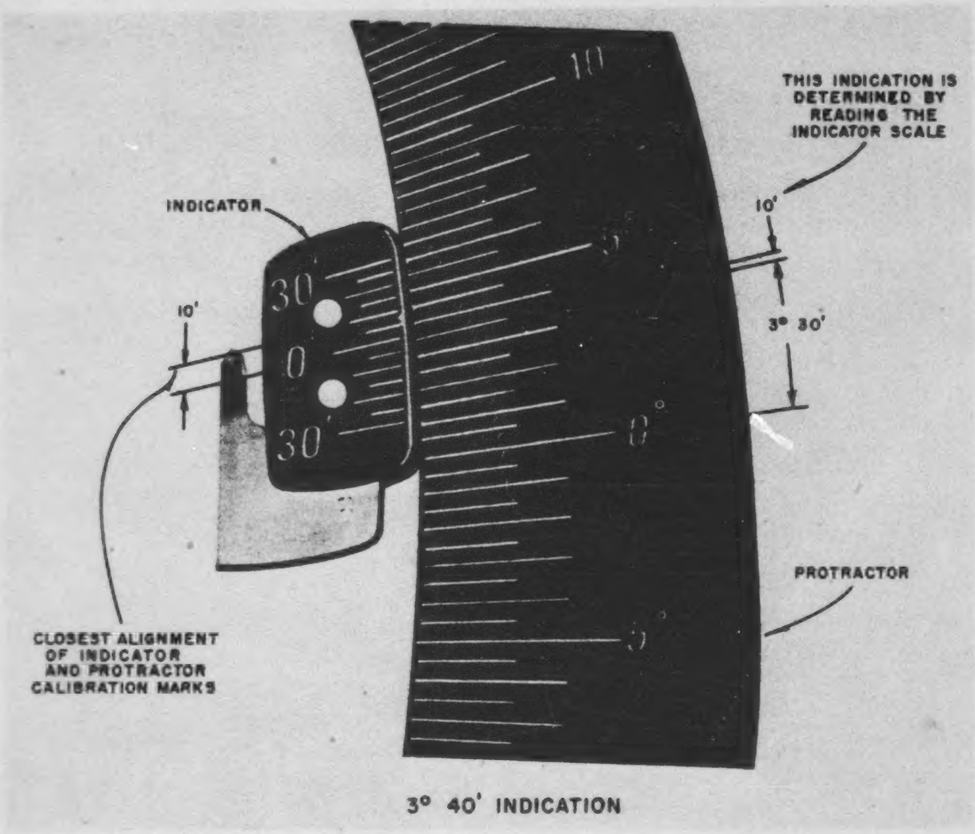
3. Add 3 degrees 30 minutes and 10 minutes to obtain the true indication of 3 degrees 40 minutes up travel.

Each mode of operation that may have been affected by alignment, or malfunction and subsequent repair action must be operationally checked and the success of the checkout verified by a qualified quality assurance representative.

Variations in lengthy step-by-step procedures for alignment and operational testing of the flight control systems make it impractical to provide an example in this section. All maintenance, including alignment, operational testing, and component replacement, must be in accordance with the instructions provided in the applicable Maintenance Instructions Manual.

SECONDARY FLIGHT CONTROLS

Secondary flight controls such as wing flaps and speed brakes are usually hydraulically operated and either mechanically or electrically controlled. These flight controls are designed to


10
THIS INDICATION IS DETERMINED BY READING THE INDICATOR SCALE
INDICATOR
10'
30
0
30
5°
10'
3° 30'
0°
PROTRACTOR
5°
CLOSEST ALIGNMENT OF INDICATOR AND PROTRACTOR CALIBRATION MARKS
3° 40' INDICATION

216.167

Figure 9-23.—Aileron throw protractor indications (A-7).

slow the aircraft in flight and to provide additional lift and stability where required. These design features greatly increase the versatility and performance of the aircraft.

WING FLAP SYSTEM

A flap is a hinged or pivoted section forming the rear portion of an airfoil, used to vary the effective camber. Wing flaps in their most commonly used form are hinged sections of the trailing edges of a wing and generally extend from the fuselage to the inboard side of the aileron. Wing flaps are connected to the main wing by various kinds of hinges and slides, and many different kinds of relative movement exist between the flaps and the wing.

The flap system discussed in this section is a representative system. The number of flaps will vary according to the size of the aircraft. The components may have different names depending on the manufacturer, but the operational theory remains the same. This system consists of a series of six flaps, three on the trailing edge of each wing. They are raised and lowered in the conventional manner by a hydraulically actuated linkage of bellcranks, pushrods, and idlers. The system is mechanically controlled with a flap control lever in the cockpit. The lever is connected by conventional and teleflex cables to the hydraulic actuating mechanism.

An emergency system is provided whereby the flaps can be lowered by operating a handpump if the primary system malfunctions.

The flap system is also equipped with a position indicator and several safety devices to prevent lowering of the flaps while the wings are folded, or folding of the wings while the flaps are down.

Operation

The flaps are set in motion by movement of the flap selector lever in the cockpit. Moving the selector lever operates a cable quadrant to which is attached a set of conventional control cables. These cables are connected to another sector just forward of the main wing beam. A teleflex cable also attached to this aft sector and a spring-loaded pushrod on the main flap actuating bellcrank connect to the two ends of a short floating arm installed on the hydraulic selector valve lever. Figure 9-24 is a drawing of the cylinder, linkage, and selector valve installation. Reference to the index numbers on this drawing is made in the following description of the operation of the flap control system.

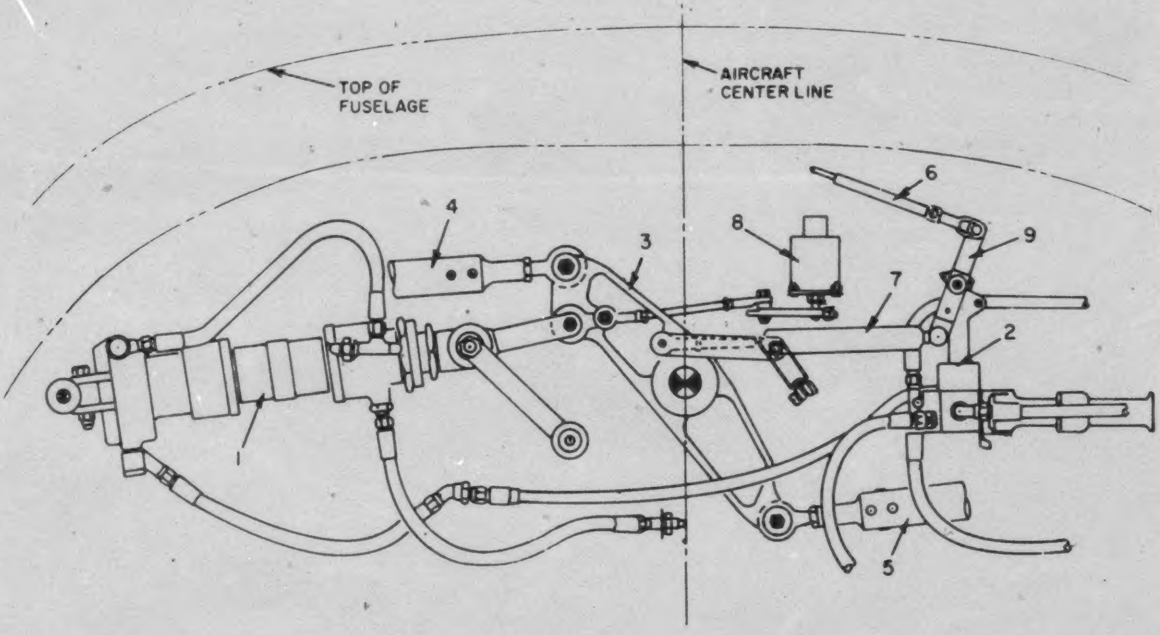
When the flap handle in the cockpit is pulled down, the upper end of the floating arm (9) is pulled to the left, pivoting at its lower end and moving the selector valve lever to the left. This action directs pressure from the hydraulics system to the flap actuating cylinder (1). The cylinder piston rod extends and lowers the flaps by rotating the flap drive bellcrank (3) in a clockwise direction. As the bellcrank moves, the lower end of the floating arm is moved to the right by the spring-loaded pushrod (7). This action pivots the arm at its upper connection to the sector pushrod and returns the selector valve to neutral, stopping the action of the system.

Moving the flap handle upward reverses the foregoing procedure by pushing the selector valve lever to the right, directing hydraulic pressure to the retract side of the cylinder piston and raising the flaps. The followup rod then moves the lower end of the floating arm to the left and returns the selector valve to neutral. The valve will not return completely to neutral, thus maintaining pressure in the flap cylinder and ensuring positive locking of the flaps in the up position.

The spring mechanism in the followup rod normally does not function. The spring mechanism is provided only as a safety feature permitting actuation of the flap drive crank by emergency hydraulic power in the event the selector valve becomes jammed.

The flap hydraulic system (fig. 9-25) consists primarily of the selector valve and the actuating cylinder. The selector valve is a four-way poppet-type valve, the poppets being actuated in pairs to direct pressure to one side of the cylinder while opening the other side to reservoir return.

The cylinder is double-acting and is internally locked in the retracted (flaps up) position. The cylinder is also provided with an integral shuttle valve (built into the mounting end cap) which provides the separation between the normal and emergency hydraulic pressure



1. Wing flap cylinder.
2. Wing flaps selector valve.
3. Flap actuating bellcrank.
4. Left flap control pushrod.
5. Right flap control pushrod.
6. Flap control push-pull cable assembly.
7. Followup pushrod.
8. Flap position transmitter.
9. Selector valve floating arm assembly.

216.168

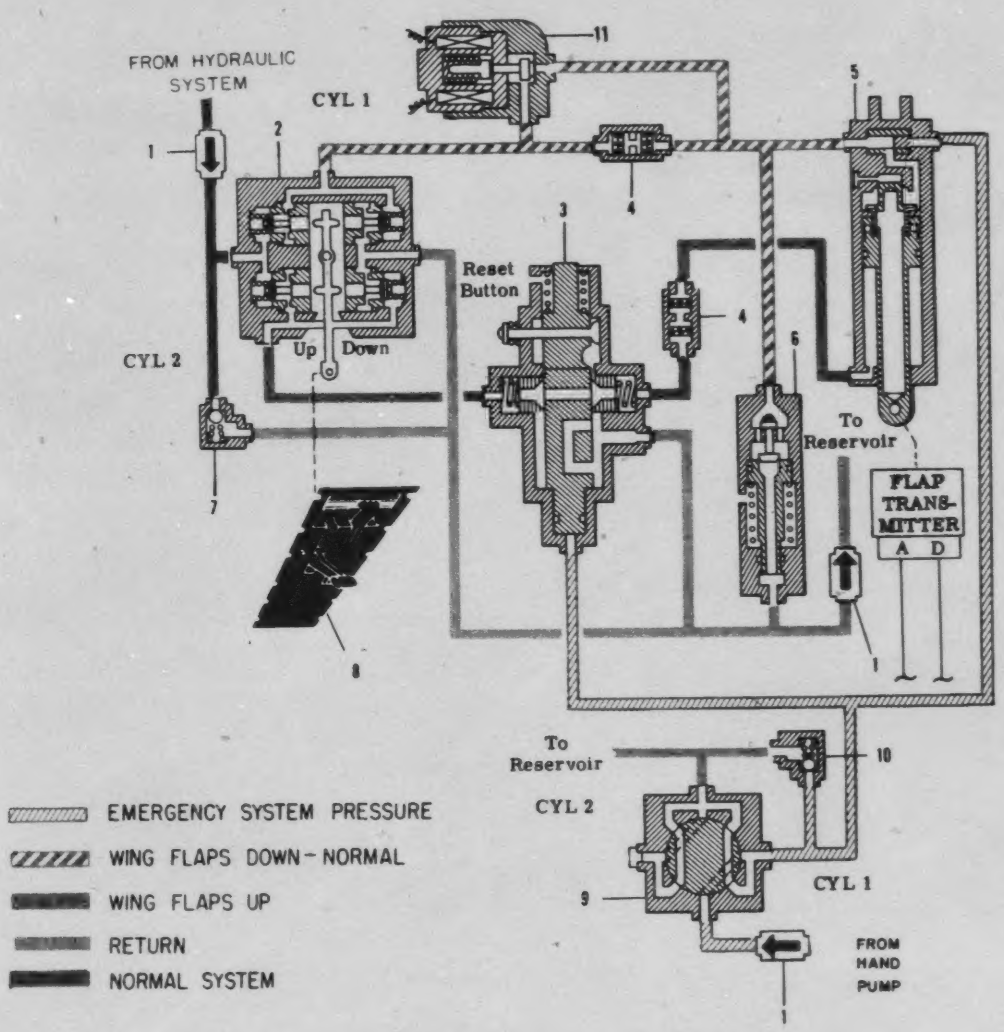
Figure 9-24.—Flap cylinder, linkage, and selector valve installation.

lines. An adjustable terminal on the piston rod provides for length variation.

When the cylinder is extended, the internal lock is hydraulically released, allowing the piston to move. When the flaps are raised, the hydraulic pressure on the lock is relieved and a compression spring engages the lock mechanism with the piston when the cylinder becomes fully retracted.

A relief valve installed in the normal flap down line provides a blowup feature which prevents overloading of the flaps and flap linkage. This valve is adjustable to a narrow range between full flow and reseat, providing a controlled blowup feature. As the flaps blow up, the flap airload decreases, gradually reseating the relief valve and preventing further flap retraction.

In the landing configuration, the flaps are partially or fully down. Safety microswitches prevent folding of the wings until the flaps are in the full up position. In order to reduce the recovery interval aboard ship it is essential that the aircraft wings be folded and the aircraft taxied forward as quickly as possible. To expedite flap retraction, a wing flap retraction shutoff valve is installed in the flap down line. This hydraulic, solenoid-operated shutoff valve is normally closed and is energized only when the weight of the aircraft is on the wheels. When energized, the valve permits return fluid to bypass the restrictor in the down pressure line


FROM HYDRAULIC SYSTEM
CYL 1
11
5
1
2
4
3
Reset Button
4
6
CYL 2
Up
Down
To Reservoir
FLAP TRANSMITTER
A
D
7
8
1
To Reservoir
10
CYL 2
9
CYL 1
FROM HAND PUMP
1
EMERGENCY SYSTEM PRESSURE
WING FLAPS DOWN-NORMAL
WING FLAPS UP
RETURN
NORMAL SYSTEM

1. Check valve.
2. Wing flap selector valve.
3. Wing flap emergency dump valve.
4. Restrictor.
5. Wing flap cylinder.
6. Wing flap blowup relief valve.
7. Wing flap thermal relief valve.
8. Wing flap control.
9. Wing flap emergency selector valve.
10. Relief valve.
11. Wing flap snap shutoff valve.

216.169

Figure 9-25.—Wing flap system.

thereby permitting fast retraction of the flaps and quicker wing fold operation.

A relief valve (located in the pressure line ahead of the flap normal system selector valve) is used to relieve any effects from thermal expansion which may build up on the inlet side of the selector valve.

An emergency system for flap down operation incudes a selector valve and an emergency dump valve. The emergency flap down selector valve is usually in the NORMAL position, venting the cylinder emergency line to return. Upon moving the emergency selector valve handle to the FLAPS DOWN position the flaps may be lowered by actuating the handpump. This action directs handpump pressure through the integral shuttle valve to the actuating cylinder and simultaneously actuates the emergency dump valve. The emergency dump valve then opens the up side of the cylinder directly to return and closes off its normal return line through the selector valve.

Once actuated, the dump valve must be reset manually to restore the system to normal operation. The emergency selector valve handle must first be returned to the NORMAL position, relieving the pressure in the emergency line. The dump valve is then reset by pushing the button on the dump valve marked PUSH TO RESET. With pressure in the normal system, the normal selector handle must be placed in the down position to reset the integral shuttle valve. The flaps may then be raised by the normal control, provided the flap up portion of the system is operative. There are no provisions for emergency retraction of the flaps.

WING FLAP AND SLAT SYSTEMS

Several aircraft within the Navy inventory are equipped with flap systems that feature both trailing edge and leading edge flap panels. On some aircraft these leading edge panels are referred to as slats.

The F-4 aircraft provides an example of a trailing edge and leading edge flap arrangement and additionally combines flap operation with aileron drooping and boundary layer control features to achieve even greater lift and stability than can be accomplished with flaps alone.

The A-6 aircraft provides an example of lift and stability being improved by semi-independent flap and slat systems, which are raised and lowered using hydraulic motors, drive units, torque tubes, and screwjack type actuators. Both types of systems are discussed in this section.

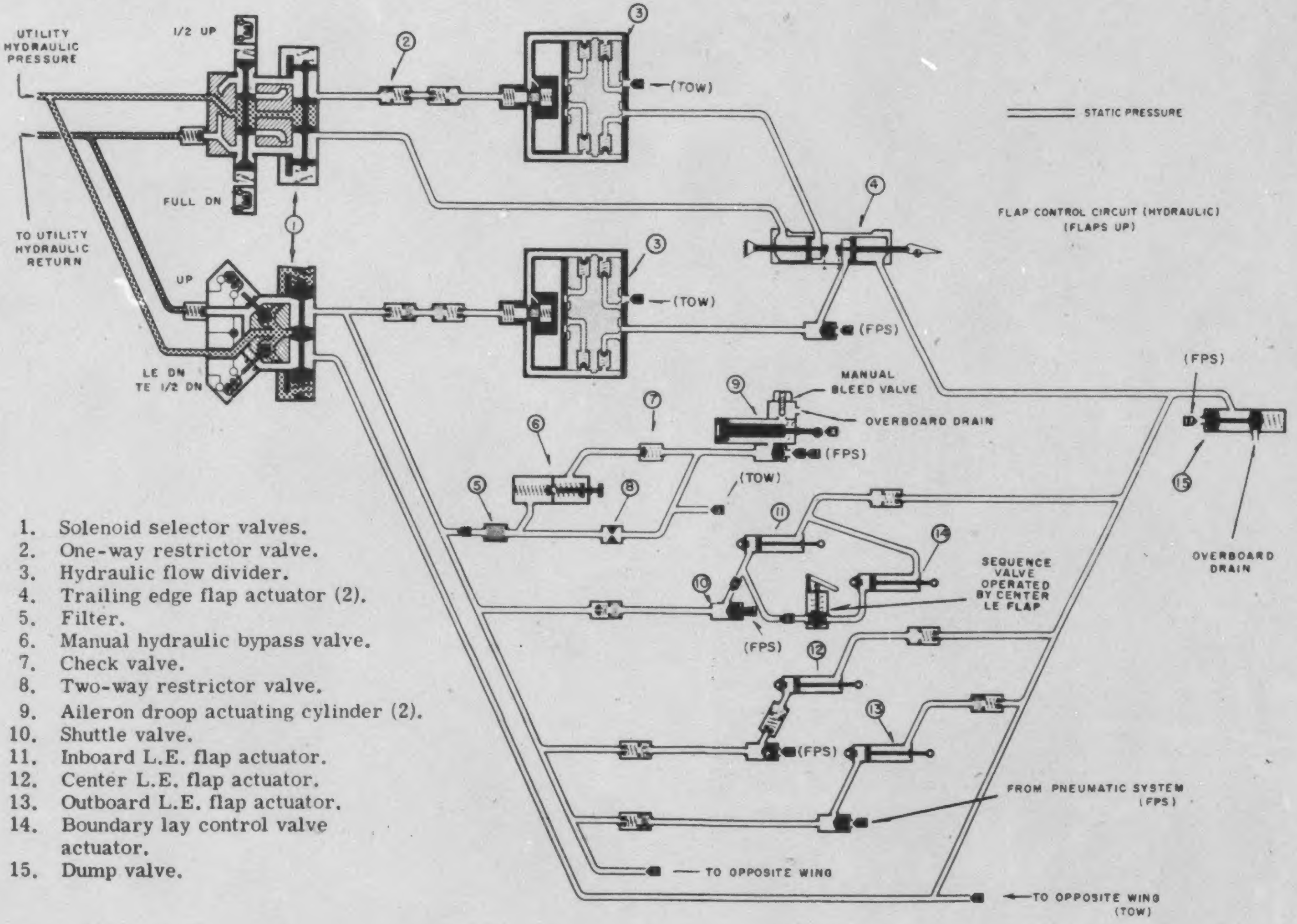
Description/Operation (F-4)

The flap system consists of three leading edge and one trailing edge flap panels for each wing with each panel having its own actuator. A three-position flap control switch in the cockpit is labeled UP, 1/2, and DN. Figure 9-26 provides an illustration of the flap control circuit hydraulic components.

The leading edge flaps are operated by a manifold-mounted selector valve and dual actuating cylinders. Trailing edge flaps utilize this same selector valve plus a wing-mounted selector valve and dual tandem actuating cylinders.

When the flap control switch is placed in the 1/2 position, the manifold-mounted selector valve directs utility system pressure through the shuttle valves and into the down lines of the leading edge flap actuators. The leading edge flaps are lowered to the full down position. The inboard leading edge flap deflection is 30 (+0, -2) degrees; center flap deflection is 60 (+0, -2) degrees; and outboard flap deflection is 55 1/2 (±1/2) degrees.

At the same time, hydraulic fluid flows through the fuselage-mounted flow divider and into the extend side of the dual tandem trailing edge flap actuating cylinder, moving the trailing edge flaps to the 1/2 position with a deflection of 30 (±2) degrees. The cockpit flap position indicator indicates barber poles while the flaps are in transit and flap position at the completion of selected movement. On older version F-4s the 1/2 UP and UP limit switches are connected in parallel and deenergize the electrical circuits to the selector valves after the flaps are retracted. On later versions, the limit switches are connected into the control circuit in series to provide an indication of flap position and continuously energize the electrical circuits to maintain hydraulic pressure when the flaps are down.


UTILITY HYDRAULIC PRESSURE
1/2 UP
FULL DN
TO UTILITY HYDRAULIC RETURN
UP
LE DN
TE 1/2 DN
(TOW)
(TOW)
STATIC PRESSURE
FLAP CONTROL CIRCUIT (HYDRAULIC) (FLAPS UP)
(FPS)
(FPS)
MANUAL BLEED VALVE
OVERBOARD DRAIN
(FPS)
(TOW)
SEQUENCE VALVE OPERATED BY CENTER LE FLAP
(FPS)
(FPS)
OVERBOARD DRAIN
FROM PNEUMATIC SYSTEM (FPS)
TO OPPOSITE WING
TO OPPOSITE WING (TOW)
216.170

1. Solenoid selector valves.
2. One-way restrictor valve.
3. Hydraulic flow divider.
4. Trailing edge flap actuator (2).
5. Filter.
6. Manual hydraulic bypass valve.
7. Check valve.
8. Two-way restrictor valve.
9. Aileron droop actuating cylinder (2).
10. Shuttle valve.
11. Inboard L.E. flap actuator.
12. Center L.E. flap actuator.
13. Outboard L.E. flap actuator.
14. Boundary lay control valve actuator.
15. Dump valve.

Figure 9-26.—Flap control circuit (F-4).

Moving the flap control switch to the full down position actuates the wing-mounted selector valve, porting pressure through a second flow divider and into the down side of the retracted half of the trailing edge flap cylinder, moving the flaps from the 1/2 to the full down position of 60 (+1, -2) degrees. Both flap position indicators will indicate DN when the cycle is completed.

Placing the flap control switch to the UP position allows hydraulic pressure to be directed to the retract side of all flap actuators, raising the flaps to the full up position. Position indicators indicate UP, and the electrical control circuits and solenoids of both selector valves are deenergized.

The leading edge flaps are locked in the UP position by overcenter locking mechanism. The trailing edge flaps are locked up by internal locks within the trailing edge actuating cylinders.

Hydraulic Droop Aileron Feature

When the flap switch is placed in 1/2 or DN position, with PC 1, PC 2, and utility hydraulic power applied, the ailerons will extend 16 1/2 degrees down. The control stick will remain centered. The droop aileron actuating cylinder (fig. 9-26), one in each wing, is extended by flap down utility hydraulic pressure and retracted by springs in the cylinder when extend pressure is removed. The droop cylinder is connected between the aircraft structure and an idler bellcrank in the aileron power package linkage. With flaps up, the droop cylinder acts as a solid link. When flaps 1/2 or DN are selected, hydraulic pressure from the flap down lines enters the cylinder and extends the piston, compressing the springs within. As the cylinder extends, the idler bellcrank moves, repositioning the control lever of the aileron power control cylinder. PC 1 and PC 2 hydraulic system pressure will then extend the ailerons together to the 16 1/2-degree position. Lateral movement of the control stick operates the ailerons normally. A droop aileron limit switch is connected to the flap position indicating circuit to provide an indication of aileron position in conjunction with flaps position.

On later model F-4s, the aileron drooping feature is accomplished differently. When the flap control switch is placed in 1/2 or DN position, the droop aileron extend relay is energized. This relay completes the extend electrical circuit to the droop aileron actuators. As the actuators extend, the aileron power cylinder input levers are repositioned and both ailerons droop as before. The actuators are deenergized by the integral extend limit switch. The ailerons are free to operate normally. When the flap control switch is placed to UP, the droop aileron extend relay is deenergized and the droop actuator repositions the aileron power cylinder input levers, and both ailerons move back to their normal position. The droop actuators are deenergized at the completion of the retract cycle by the integral limit switch.

Emergency Flap

If electrical and hydraulic power fails, the flaps can be lowered by the emergency system. An emergency flap extension bottle with a 300 cubic inch capacity and charged to 3,000 psi provides a power source. Emergency extension is controlled by the emergency flap control handle that is mechanically linked to the emergency flap air selector valve. When the handle is pulled aft, the piston inside the air selector valve shifts, allowing high pressure air to flow through a separate set of lines to shuttle valves in the flap system. The shuttle valves reposition and air pressure extends the flap actuators. Air pressure also repositions the flap system dump valve, allowing return hydraulic fluid to be dumped overboard. The leading edge flaps extend to the full down position and trailing edge flaps to the 1/2 down position. On later version F-4s, the aileron drooping feature does not operate when the flaps are lowered by the emergency flap system.

Boundary Layer Control Valve Actuator

The boundary layer control valve actuator (fig. 9-26) opens boundary layer air shutoff valves within each wing when the flaps are lowered to the 1/2 or DN position. Nozzles distribute engine bleed air to the aft edge of the leading edge flaps and the forward edge of the trailing edge flaps to provide greater lift. A boundary layer control malfunction warning system provides a cockpit indication if BLC shutoff valves do not close when the flaps are raised.

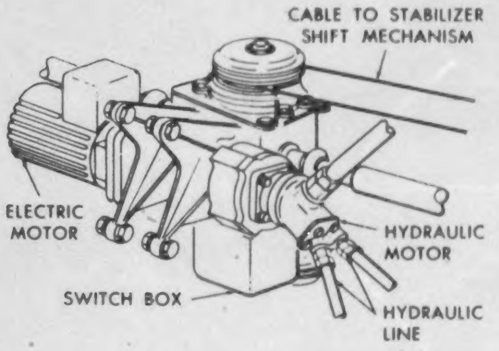
Description/Operation (A-6)

The flap and slat systems of the A-6 are independent systems. However, their operation is controlled by common cockpit controls.

FLAP SYSTEM.–The flaps are divided at the wing fold joint into two panels per wing. The panels are supported by two sets of tracks and rollers and driven by two ball screw actuators each. The flap drive motor and gearbox assembly, illustrated in figure 9-27, is powered by pressure from the combined hydraulic system.

If the combined hydraulic system fails, a hydraulic brake locks the hydraulic motor, and an emergency electric motor provides continued operation. Emergency flap extension and retraction is controlled by placing the EMERG FLAP switch, on the throttle quadrant, at either UP or DN.

Cam-operated switches within the flap drive gearbox provide input signals to show the flap position on the cockpit-integrated position indicator.



216.171

Figure 9-27.–Flap drive gearbox.

Operation of the flap control handle energizes the solenoid-operated flap selector valve, directing hydraulic pressure to the extend or retract lines of the flap drive motor. The wings must be spread and locked to provide a complete electrical circuit through the wing unlock relay to the selector valve.

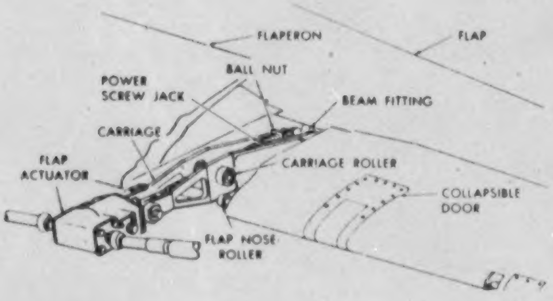
When the flap control handle is placed at TAKEOFF position, the electrical circuit is completed through the 30-degree switch and the cam-operated flap drive gearbox limit switch to the selector valve. Pressure is ported to the down side of the high-speed hydraulic motor, which drives the gearbox. The flap drive gearbox, through a series of torque tubes and offset gearboxes, drives all eight flap actuators.

The flap actuators, illustrated in figure 9-26, drive the carriage and attaching flaps out and down to the 30-degree position. The limit switch in the flap drive gearbox is opened, deenergizing the selector valve circuit, thus allowing the valve shuttle to return to neutral, blocking flow to the motor, and preventing further flap extension.

When the flap control handle is placed at LAND, the 40-degree down flap handle switch is mechanically closed. The electrical circuit to the selector valve is again completed, this time through the now closed 40-degree down limit switch in the flap drive gearbox. The flaps will extend to 40 degrees, and the electrical circuit will be broken by the action of the limit switch.

Moving the flap control handle to the TAKEOFF or UP position will energize the opposite solenoid of the flap selector valve and port pressure to the retract side of the flap hydraulic motor. If the TAKEOFF position is selected, a limit-switch will again halt flap movement at the 30-degree position. If UP is selected, retraction will be halted when the flaps reach the full up position by the action of the flaps up limit switch. At the same time, linkage from the up limit switch actuates a second switch to complete the electrical circuit to the flap hydraulic motor brake valve. The energized valve blocks combined hydraulic system pressure that is holding the hydraulic brake in the unlocked position. The brake locks the hydraulic motor which, in turn, locks the flaps in the up position.

If combined hydraulic system pressure fails and the emergency flap switch is utilized, the



216.172

Figure 9-28.–Flap actuator.

flap action is powered by the electric motor (fig. 9-27). The flap hydraulic brake valve is energized, the pressure holding the spring-loaded hydraulic motor brake unlocked will port to return. The brake is then free to lock the motor and input shaft.

The electric motor now drives the flap gearbox and associated linkage, bypassing the locked hydraulic motor until the flaps reach a 40-degree trailing edge down position. Limit switches shut the electric motor off when the flaps reach the 40-degree down and full up positions.

Flap Actuator.–The flap actuator (fig. 9-28) shifts rotary motion of the input shaft to linear flap motion through the use of bevel gears and the ball screwjack mechanism. A load-sensing device in each flap actuator actuates a clutch assembly to stall out the flap system in the event of an overload. An impact plate at the end of the ball screw (screwjack shaft) and mechanical stops on the actuator body protect the actuator against possible overtravel during flap extension and retraction.

Offset Gearboxes.–The eight offset gearboxes in the flap system transmit power produced by the flap drive gearbox around wing structure obstacles and compensate for wing angularity. They also reduce the flap drive gearbox speed of 1,080 rpm to about 550 rpm at the outboard actuators.

Flap Wing Fold Shaft.–A wing fold shaft, consisting of two interlocking splined sections and two universal joints connected to quill shafts, provide a telescoping fold joint in the flap drive system linkage between the inboard and outboard wing panels.

SLAT SYSTEM.–The slat system, illustrated in figure 9-29, provides additional lift and stability to the aircraft at lower speeds in the same manner as the leading edge flap system previously discussed. Movement of the slats is controlled by the flap control handle. Moving the flap control handle to the TAKEOFF or LAND position causes the slats to extend to a 27.5-degree leading edge down position.

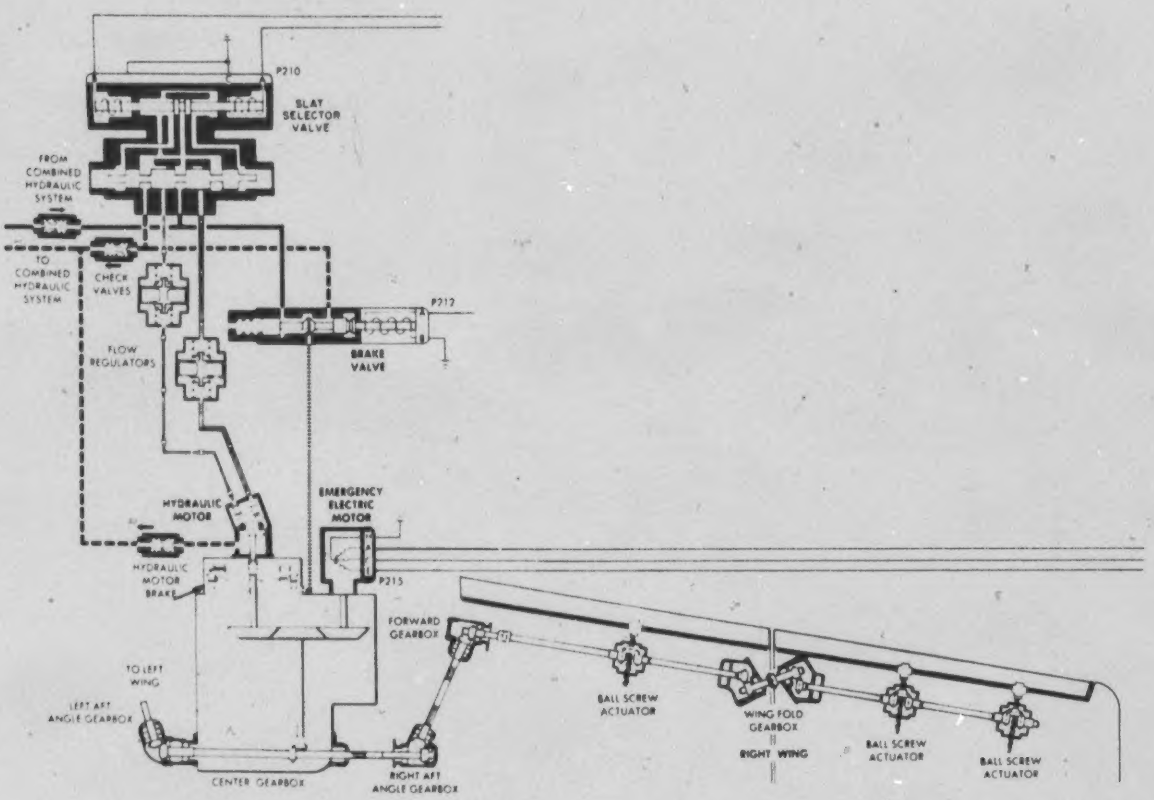
The slat panels, one inboard and one outboard, are interlocked by a pin when the wings are spread. When fully retracted, the slats align with the top and bottom wing contours to form the wing leading edge. Shim spacers between the slats and the slat tracks provide adjustment for proper aerodynamic fairing.

Components of the slat system are similar to those in the flap system. The slats are extended and retracted by six series-linked ball screw actuators. The actuators are powered by the hydraulic-motorpowered gearbox through torque tubes and angle gearboxes.

In the event combined hydraulic system pressure fails, the hydraulic motor is locked in the same manner as the flap hydraulic motor, permitting the emergency electric motor to move the slats. Emergency slat operation is accomplished simultaneously with emergency flap operation, using the emergency flap switch. Slat position is also displayed on the cockpit integrated position indicator.

Placing of the flap control handle to either the TAKEOFF or LAND position mechanically closes switches to provide electrical current to the slat selector valve. The energized selector valve solenoid positions the valve shuttle and ports hydraulic pressure to the extend side of the high-speed hydraulic motor, driving the center gearbox and extending the slats.

Two ball screw actuators drive each outboard slat, and one drives each inboard slat of each wing. Each actuator is connected to its downstream actuator by torque tubes and gearboxes; thus, the slats move as one unit.


P210
SLAT SELECTOR VALVE
FROM COMBINED HYDRAULIC SYSTEM
TO COMBINED HYDRAULIC SYSTEM
CHECK VALVES
P212
FLOW REGULATORS
BRAKE VALVE
HYDRAULIC MOTOR
EMERGENCY ELECTRIC MOTOR
HYDRAULIC MOTOR BRAKE
P215
FORWARD GEARBOX
TO LEFT WING
LEFT AFT ANGLE GEARBOX
BALL SCREW ACTUATOR
WING FOLD GEARBOX
RIGHT WING
BALL SCREW ACTUATOR
BALL SCREW ACTUATOR
CENTER GEARBOX
RIGHT AFT ANGLE GEARBOX

216.173

Figure 9-29.—Slat drive system.

Limit switches in the center drive gearbox deenergize the slat selector valve, blocking flow to the drive motor, when the slats are fully extended (27.5 degrees) or retracted.

Placing the flap control handle to the UP position energizes the opposite solenoid of the selector valve and reverses slat motor direction, thus retracting the slats.

Slat Wing Fold Gearbox.—A wing fold gearbox is used to disconnect slat drive linkage at the wing fold joint when the wings are folded. The gearbox consists of two identical halves interconnected by a spring-loaded disconnect coupling when the wings are spread. As the disconnect coupling halves move away from each other during the wing folding operation, a spring-operated brake is engaged, preventing relative motion between the inboard and outboard sections.

Slat Angle Gearboxes.—Four slat angle gearboxes are provided in the slat system for changing direction of the slat torque tube linkage from the center gearbox to the wing actuators.

Maintenance Concept

Organizational maintenance of the flap and slat systems includes checking system operation, rigging, periodic inspection, lubrication, isolation of malfunctions, and replacement of faulty components.

Proper operation of the gearboxes, interconnecting splined shafts, and screwjack actuators is dependent on proper lubrication. Lack of proper lubrication will generally result in binding, excess loading of torque tube assemblies, and promotion of corrosion. Space and time limitations during shipboard operations often detract from the timely access to some of the slat and flap actuators. In many cases a wing spread and extension of the surfaces is necessary. Attention to these corrosion-prone areas will materially contribute to trouble-free operation of the screwjack mechanisms and the structural integrity of normally hidden areas that are open to salt spray during carrier landings and takeoffs.

Repair of most of the gearboxes and screwjack actuators at the intermediate level of maintenance is limited to replacement of nuts, bolts, washers, gaskets, bearings, and shims.

At the intermediate level of maintenance, components of the flap and slat hydraulic system may be disassembled for routine maintenance such as cure date seal and miscallaneous parts replacement.

NOTE: Prior to disassembly of any component, reference should be made to the Intermediate Maintenance section of the applicable Maintenance Instructions Manual or Accessories Manual to determine repair procedure and test equipment requirements. If the component is beyond the repair capability of a given activity, it should be forwarded through channels to an authorized higher level repair activity.

The repair process for many of the flap hydraulic components will generally include the following considerations:

Cleaning of the disassembled part, using a suitable solvent followed by air drying with low-pressure air.

Inspection of all parts, using a strong light and some means of magnification or one of the nondestructive methods of metal inspection. Threaded parts are inspected for crossed, stripped, worn, or otherwise damaged threads. Springs are checked for distortion, permanent set, and alignment. Spring alignment may be verified by rolling them on a smooth flat surface. The free length, compressed length, and reflected load of the springs should be verified in accordance with the values provided in the applicable Maintenance Instructions Manual.

Mated surfaces should be inspected for excessive wear, separation of plating, and evidence of nicks or scratches. All parts that show signs of excessive scoring, pitting, or other surface irregularities should be replaced. Minor imperfections can sometimes be removed with fine crocus cloth or lapping compound, depending on the design and tolerance specifications of the component.

Ensure that all passages and chambers of the component being repaired are clean and free from obstructions.

NOTE: During the complete repair process, cleanliness of the work area, as well as the component and its internal parts, is a prime consideration. The close tolerance mated surfaces within most hydraulic components are extremely susceptible to damage by contamination irrespective of the manner in which it is introduced.

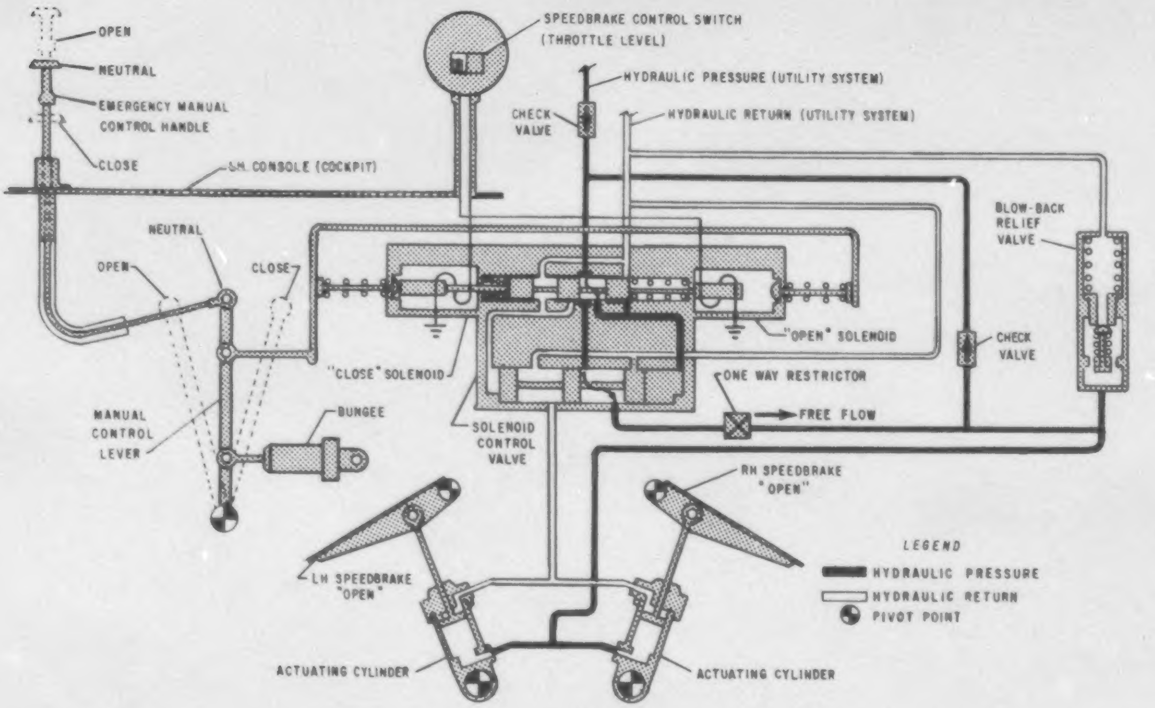
Following reassembly, the flap component must be bench-tested to verify its proper performance. In most cases, testing will include proofing testing, leakage testing to verify proper internal seal operation, and operational testing.

Quality accurance verification is required throughout the repair process and at the completion of repair. All repairs must be accomplished as specified in the Intermediate Repair section of the applicable Maintenance Instructions Manual or 03 Manual. Steps that require quality assurance verification are so indicated by appearing in italics, being underlined, or some other obvious manner.

Following repair, the component is partially filled with Mil-H-6083, preservative hydraulic fluid, and capped and/or plugged to prevent contamination.

SPEED BRAKE SYSTEMS

Speed brakes are hinged, movable secondary control surfaces used for slowing down the speed of the aircraft by increasing the profile drag. These surfaces are also called dive brakes or dive flaps. On some aircraft, they are hinged to and faired with the side or bottom of the fuselage; on others they are attached to the wings. Regardless of their location, their purpose


OPEN
NEUTRAL
EMERGENCY MANUAL CONTROL HANDLE
CLOSE
SH. CONSOLE (COCKPIT)
SPEEDBRAKE CONTROL SWITCH (THROTTLE LEVEL)
HYDRAULIC PRESSURE (UTILITY SYSTEM)
CHECK VALVE
HYDRAULIC RETURN (UTILITY SYSTEM)
BLOW-BACK RELIEF VALVE
NEUTRAL
OPEN
CLOSE
"OPEN" SOLENOID
CHECK VALVE
"CLOSE" SOLENOID
ONE WAY RESTRICTOR
FREE FLOW
MANUAL CONTROL LEVER
BUNGEE
SOLENOID CONTROL VALVE
RH SPEEDBRAKE "OPEN"
LEGEND
HYDRAULIC PRESSURE
HYDRAULIC RETURN
PIVOT POINT
LH SPEEDBRAKE "OPEN"
ACTUATING CYLINDER
ACTUATING CYLINDER

216.174

Figure 9-30.—Speed brake control system.

is the same. The fuselage speed brake system for the A-4 aircraft and the wingtip speed brake system for the A-6 aircraft are discussed in this section.

Fuselage Type

The fuselage speed brake system of the A-4 (fig. 9-30) is normally electrically controlled and hydraulically actuated. In an emergency, it can be controlled manually.

The brake surfaces are installed on the sides of the aft portion of the fuselage below and forward of the horizontal stabilizer. They are hinged at their forward end; and when in the closed position, they fit into a recess and are flush with fuselage skin. An elevator speed brake interconnect, consisting of a cable, springs, and a cable sector, provides a connection between the left-hand speed brake and the aircraft nosedown elevator control cable. When the speed brakes are opened, the cable is pulled and provides a nosedown action to counteract the tendency of the aircraft to assume a noseup condition, which is caused by the speed brake force on the aircraft.

The speed brakes may be actuated by the two-position, spring-loaded-to-neutral control switch on the throttle lever or by the manual override control handle. When the switch is operated to open the speed brakes, the control circuit is energized to operate the opening solenoid of the control valve. Pressure is directed to the actuating cylinders, which extend to open the speed brakes. When the switch is operated to close, the opposite solenoid is energized to reposition the control valve shuttle and direct pressure to the retract side of the actuating cylinders, closing the speed brakes.

When the manual override handle is depressed or pulled to operate the speed brakes, a plunger manually operates the control valve to direct pressure to the actuating cylinders. The spring bungee connected to the manual control lever returns the manual override handle assembly to the neutral position when the handle is released. If electrical power is applied while the manual override handle is actuated, the system will remain in the position selected by the handle. If the handle is released, the system actuates to the position selected by the control switch on the throttle lever. The speed brakes cannot be stopped at intermediate positions between fully closed and fully open.

The restrictor in the open line restricts return fluid flow from the actuating cylinders when the speed brakes are being closed.

In the event of a hydraulic system failure, the check valve in the pressure line traps pressure between the control valve and the actuating cylinders. If the speed brakes are open, this pressure will hold them open. If the speed brakes are actuated to the closed position, the pressure in the system will shift the primary slide in the control valve, relieving the trapped pressure and allowing the speed brakes to close from the air pressure against them.

SPEED BRAKE CONTROL VALVE.–The control valve is an electrohydraulic, two-position, four-port valve consisting of two primary and two secondary slides. The solenoids on each end of the valve actuate the primary slides which, when moved, direct pressure to move the secondary slide. The secondary slide directs pressure through the valve to the actuating cylinders.

BLOWBACK RELIEF VALVE.–This valve is installed in the hydraulic return line to allow for automatic retraction of the speed brakes under high airloads. When the speed brakes are open, the force of the airstream against the surfaces tends to force them closed. The force builds up the hydraulic pressure in the speed brake system; and when the pressure reaches a maximum of 3,650 psi, it is relieved through the blowback relief valve.

Wingtip Type

The wingtip speed brake system of the A-6 (fig. 9-31) is an electrically controlled and hydraulically operated system that may be used either alone or in conjunction with the fuselage speed brakes. Only the wingtip speed brakes are covered in this section.

The wingtip brake consists of a set of trailing edge surfaces for each wing. The lower half is attached to the wing structure with two external fixed hinges. The upper half is attached to the wing at the same wing station, with two adjustable tension lengths. An interconnecting hinge, between the upper and lower halves, provides a common connection point for the actuating cylinders, thus providing symmetrical deflection of upper and lower panels. Each panel is capable of opening up to 60 degrees for an included angle of 120 degrees for each wingtip brake. When retracted, they lie flush with the wing surface. They can be extended and held at any angle between 0 and 60 degrees, depending upon the amount of aerodynamic braking desired.

A mode selector switch is utilized to permit simultaneous or independent operation of the wingtip and fuselage speed brakes with the speed brake control switch located on the right throttle quadrant power lever. Moving the SPD BRK switch to the forward position closes the brakes, moving it to center position holds the brakes at any desired angle, and moving it aft opens the brakes. The switch is spring-loaded to neutral from the aft position only.

When the open position is selected, the selector valve is energized to port hydraulic pressure from the combined hydraulic system to the extended side of the actuating cylinder. When the switch is positioned to closed, the opposite solenoid is energized and pressure is ported to the retract side of the actuating cylinders. When the switch is at neutral, hydraulic fluid is blocked from both the extend and retract sides of the speed brake cylinders, thus hydraulically locking the speed brakes. In the event of an electrical circuit failure, the selector valve is deenergized as a fail-safe feature and the speed brakes retract.

The wingtip speed brake control system normally depends upon the hydraulic flow regulators to maintain symmetrical extension of the left and right brakes. If a malfunction, such as an internal leaking actuating cylinder, causes asymmetry of extension, an electrical disparity

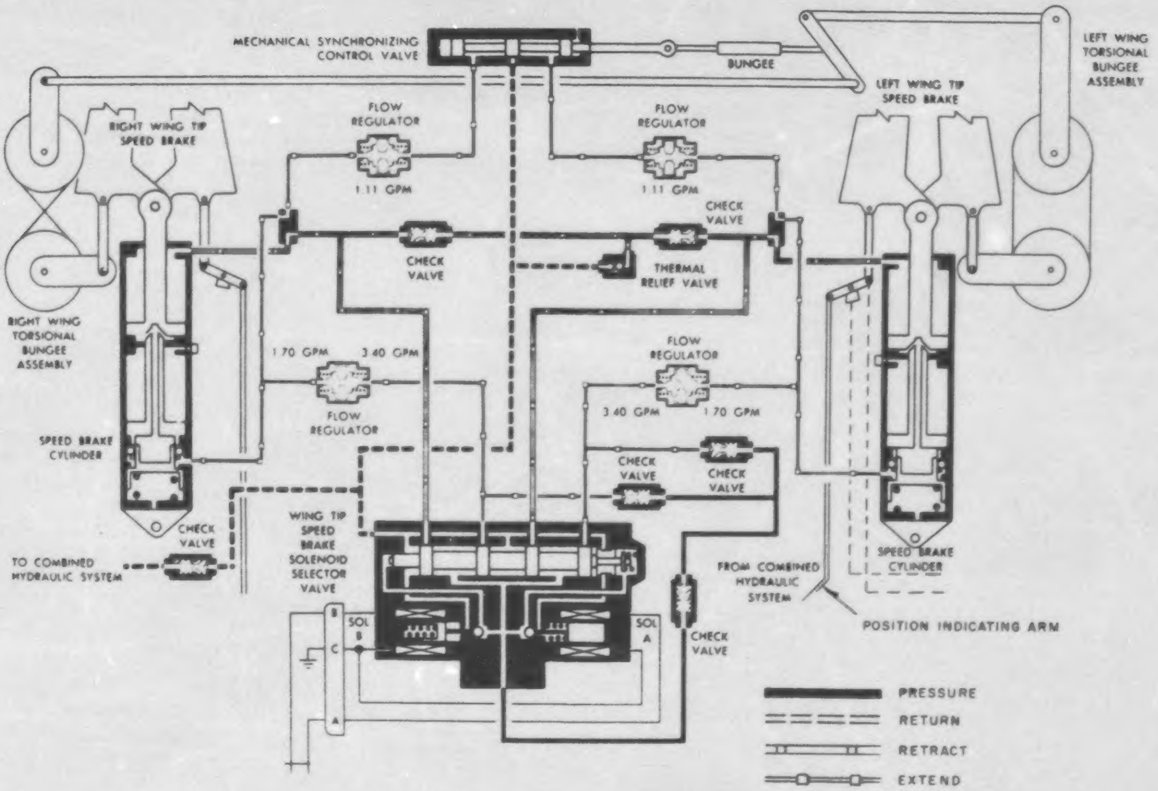

MECHANICAL SYNCHRONIZING CONTROL VALVE
BUNGEE
LEFT WING TORSIONAL BUNGEE ASSEMBLY
LEFT WING TIP SPEED BRAKE
RIGHT WING TIP SPEED BRAKE
FLOW REGULATOR
1.11 GPM
FLOW REGULATOR
1.11 GPM
CHECK VALVE
CHECK VALVE
THERMAL RELIEF VALVE
RIGHT WING TORSIONAL BUNGEE ASSEMBLY
1.70 GPM
3.40 GPM
FLOW REGULATOR
FLOW REGULATOR
3.40 GPM
1.70 GPM
SPEED BRAKE CYLINDER
CHECK VALVE
CHECK VALVE
WING TIP SPEED BRAKE SOLENOID SELECTOR VALVE
CHECK VALVE
TO COMBINED HYDRAULIC SYSTEM
FROM COMBINED HYDRAULIC SYSTEM
SPEED BRAKE CYLINDER
POSITION INDICATING ARM
SOL B
SOL A
B
C
A
CHECK VALVE
PRESSURE
RETURN
RETRACT
EXTEND

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Figure 9-31.—Wingtip speed brake control system.

signal is sensed by the speed brake null detector. When the disparty between the extension of the left and right brake reaches 8 degrees, the null detector deenergizes the selector valves and causes the speed brakes to close.

On some model A-6s, the synchronization mechanism (fig. 9-31) consists basically of synchronizing linkage, two torsional bungee assemblies, and a cable run interconnecting the three mechanisms to a mecahnical synchronizing control valve. The synchronizing mechanism is of the comparative linkage type that senses unequal motion between the two brake surfaces. Movement of either speed brake is transmitted by the torsional bungee assembly, through the cables, to the synchronizing mechanism. Any unequal movement upsets the synchronizing mechanism netrual position, thus displacing the synchronizing valve shuttle. When the speed brakes are opening or closing, the valve is normally in neutral as long as the travel of both sides is equal. When unequal travel moves the valve shuttle out of neutral, the valve will relieve hydraulic pressure from the speed brake actuating cylinder, producing the largest opening angle. This decelerates the opening of the speed brake or bleeds down the speed brake with the largest angle until the disparity is within limits and the shuttle is returned to neutral. On later models this mechanical synchronization system has been deleted.

If the mechanical synchronization system fails to maintain synchronization within 8 degrees, the electrical fail-safe system operates

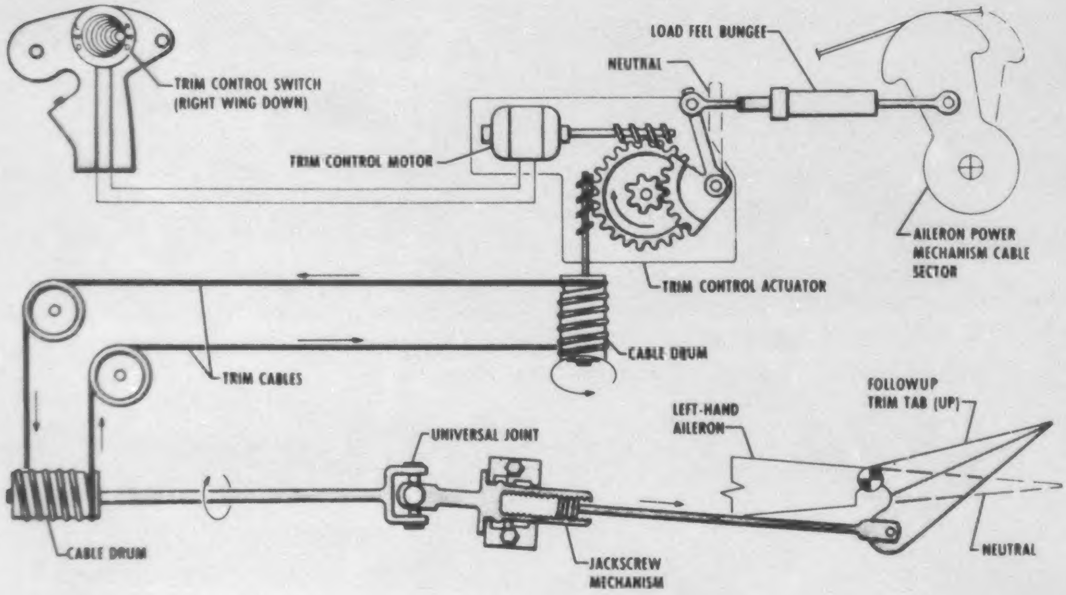
TRIM CONTROL SWITCH
(RIGHT WING DOWN)
LOAD FEEL BUNGEE
NEUTRAL
TRIM CONTROL MOTOR
AILERON POWER MECHANISM CABLE SECTOR
TRIM CONTROL ACTUATOR
CABLE DRUM
TRIM CABLES
FOLLOWUP TRIM TAB (UP)
LEFT-HAND AILERON
UNIVERSAL JOINT
CABLE DRUM
JACKSCREW MECHANISM
NEUTRAL

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Figure 9-32.–Aileron trim control system–functional schematic.

and deenergizes the selector valve to close the speed brakes.

If the synchronizing linkage becomes jammed, the torsional bungee assembly can be forced out of detent, thus isolating the linkage from the speed brake and preventing damage to the linkage due to overloads.

The bungee in the synchronizing mechanism linkage acts as a rigid length to the synchronizing valve during wingtip speed brake normal operation. If the valve becomes jammed, abnormal loads on the bungee will cause it to give and relieve the excessive loads before damage to the valve, linkage, or bungee occurs.

TRIM SYSTEMS

Trim systems are provided in the flight controls to alleviate the necessity for constant effort on the part of the pilot to maintain the desired heading and altitude and in effect, stabilize the aircraft in flight.

Lateral Trim

The A-4 aileron trim control system, illustrated in figure 9-32, represents a trim tab arrangement similar to that which is found on aircraft equipped with conventional aileron systems.

Operation of the lateral and longitudinal trim systems, in most cases, is controlled by a five-position, four-throw, momentary ON contact switch with a center OFF position, located on the control stick grip. This switch electrically energizes the trim control motor, which operates the trim control actuator to reposition the load feel bungee and achieve hydraulic-powered actuation of the ailerons. At the same time, the actuator operates the cable drum mechanism, which actuates the jackscrew mechanism to reposition the followup trim tab to aerodynamically maintain the aileron surface in a position corresponding to that achieved by the hydraulic actuation.

The tab movement does not control the lateral trim of the aircraft while normal powered flight is maintained. This is accomplished by the hydraulic-powered displacement of the ailerons. When the power mechanism is disconnected and the manual flight control system is used, the followup trim tab position introduced during powered operation becomes effective and aerodynamically maintains relatively the same trim as that provided by the powered operation.

With the power system disconnected, further hydraulic trim control is terminated, and all future trim inputs are achieved through aerodynamic effect, which is dependent upon selective followup tab position. When the automatic flight control system is engaged, the trim actuator is controlled by electrical inputs from the AFCS.

Aircraft without trim tabs achieve lateral trim by repositioning the lateral control surfaces as necessary to achieve a balanced lateral flight condition. The A-7 aircraft represents an example of this type trim mechanism. Referring back to figure 9-8, the trim actuator is located in the aileron trim and mixing linkage and normally acts as a series-connected, fixed-length rod in the aileron control system. The actuator length is controlled by the trim control switch on the stick grip. Shortening or retracting the trim actuator, trim button to the right, supplies a left wing up input into the aileron control system linkage. Extending the actuator supplies a left wing down input. The trim actuator changes the neutral position of the aileron mechanism, thus allowing the control surfaces to be deflected and trimming the aircraft without deflecting the control stick.

Longitudinal Trim

Longitudinal or pitch trim can be accomplished in several ways. On aircraft with a nonmovable horizontal stabilizer, trim could be provided by a trim tab arrangement or deflection of the elevators in much the same manner as described for the lateral trim systems.

Aircraft with a movable horizontal stabilizer and elevators, such as the A-4, are longitudinally trimmed by changing the angle of incidence of the stabilizer. Moving the 4-way trim control switch on the stock grip fore or aft will raise or lower the leading edge of the stabilizer to provide the angle of incidence necessary for balanced flight. Movement of the stabilizer is provided by an electric trim motor and actuator arrangmenet.

Aircraft utilizing a movable horizontal stabilizer for longitudinal control are trimmed by varying the neutral position of the control linkage, which in turn relocates the surface. For example, longitudinal trim of the A-6 (fig. 9-14) is provided by varying the position of the artificial feel bungee, thus repositioning the linkage and establishing a new neutral position for the stabilizer linkage. Any time a new neutral is introduced by the trim actuator, the power valve shuttle is displaced and the stabilizer assumes a new neutral location, changing the attitude of the aircraft. The trim inputs may be provided by the pilot or the automatic flight control system. The actuator has two operating speeds. High speed is used for manual trim and low speed for AFCS trim.

Directional Trim

Directional trim is necessary to compensate for yaw of the aircraft. Rudder trim for the A-4 is basically similar to the aileron trim. When the momentary throw rudder trim switch is moved left or right, the trim actuator is energized to move the load feel bungee, repositioning the rudder power mechanism input crank. The rudder linkage and the rudder are repositioned accordingly to a new neutral position.

Most aircraft with power-controlled actuators work in a similar manner, utilizing an electric trim actuator to change the neutral position of linkage, thus deflecting the rudder to maintain the desired directional stability. Like the lateral and longitudinal trim systems, rudder trim action can be initiated manually or automatically.

Trim position indicators provide a cockpit indication of the amount of trim or surface deflection required by each trim system.

REMOVAL AND INSTALLATION OF WINGS AND STABILIZERS

The primary flight control surfaces and some of the secondary control surfaces are attached to the wings and stabilizers of the aircraft. In many instances, the wings and stabilizers are damaged beyond repair. When this occurs, they must be removed and sent to a depot level maintenance facility for repair, and a replacement installed.

PROCEDURE FOR REMOVAL AND INSTALLATION OF WINGS

Removal and installation of a wing is a major operation requiring experienced personnel and close supervision by a senior petty officer.

The airframes section of the applicable Maintenance Instructions Manual should be read carefully before attempting to remove a wing. This manual will give step-by-step instructions for wing removal and installation. It is necessary to follow these instructions to prevent possible damage caused by failure to disconnect or connect units in the proper sequence.

Listed below are some general precautions which should be observed in removing and installing a wing or wing section.

Removal precautions:

1. The aircraft should be placed in a hangar or other area protected from the wind.
2. Make certain all the necessary equipment is available and at hand. (A list of the necessary special tools and equipment will be found in the applicable Maintenance Instructions Manual.)
3. Ensure that sufficient manpower is at hand for proper handling.
4. See that all screws, bolts, and other removed fasteners are placed in containers and properly marked to prevent loss.
5. Removed fairing should be marked and stowed in a safe place.
6. In disconnecting tubing, electrical connectors, control cables, bonding wires, and the like, see that the instructions given in the aircraft Maintenance Instructions Manual are carried out.
7. Make certain that all disconnected tubing is capped.
8. If hoisting equipment is to be used, be sure that it is in good condition and that a qualified operator is available. Also ensure that the hoist fittings are properly installed. Some wings will not balance at their hoist fittings, making it necessary to attach guide ropes to keep the wing steady after it is disconnected from the aircraft.
9. Before attempting to remove any structural bolts, make certain that the wing is properly supported, with all loads removed from the fittings. A mallet and brass drift pin may be used in removing these bolts.
10. After the wing is removed from the aircraft, all fittings, connections and unremoved structural members should be inspected for secondary damage before installing the new wing or wing section. (Secondary damage is damage to adjacent structure which may have resulted from the transmission of the shock or load which caused the primary damage.)
11. Before installing the new wing, advantage should be taken of improved accessibility to inspect for and repair corrosion damage and renew preservative coatings in heretofore inaccessible areas.

The petty officer in charge should see that the following general precautions are taken in installing a wing or wing section:

1. Check the identification tag of the new assembly, making sure it is the correct replacement unit.
2. See that extreme care is taken in removing it from the container, thus preventing any possible damage.
3. Inspect the new wing or wing section for possible damage incurred during shipment or removal from the container. (The container should be used for shipping the damaged wing to the depot maintenance facility.)
4. With the wing in position for installation and properly supported, see that all structural bolts are installed and the nuts properly torqued.

CAUTION: The attaching bolts should never be forced; if they bind, check alignment of the wing.

5. Make certain that all tubing, electrical connectors, control cables, and any other disconnected mechanisms are properly connected.
6. Check the operation of all mechanisms which were disconnected during removal. Make the necessary rigging adjustments in accordance with the applicable Maintenance Instructions Manual before installing access doors and fairings.
7. Make a final inspection of the completed job.

REMOVAL AND INSTALLATION OF STABILIZERS

The removal and installation of stabilizers is similar in most cases to that of wings and wing panels. On many aircraft the horizontal stabilizer is a movable airfoil, controllable from the cockpit. On some of these aircraft it is used in conjunction with the elevators to maintain longitudinal control at sonic speeds where the elevators have a tendency to lose their effectiveness. On other aircraft the movable horizontal stabilizer serves the dual purpose of elevators and stabilizers and in many instances is referred to as a stabilator.

Some aircraft have an empennage or tail group which consists of all-movable horizontal stabilizers and a single all-movable vertical stabilizer. These aircraft do not have elevators or a rudder.

The removal and installation of stabilizers, like that of the wing, are major jobs and must be accomplished with care and close supervision. Step-by-step instructions for the removal and installation of stabilizers are also included in the airframes section of the applicable Maintenance Instructions Manual. Many of the general precuations listed under "Removal and Installation of Wings" also apply to stabilizer removal and installation.

NOTE: Removal of flight control surfaces is covered in *Aviation Structural Mechanic H 3 & 2*, NAVEDTRA (Series), and should be reviewed in conjunction with this section.

TORQUING NUTS AND BOLTS

Fastener fatigue failure accounts for the majority of all fastener problems. Fatigue breaks are caused by insufficient tightening and the lack of proper preload or clamping force. This results in movement between the parts of the assembly and bending back and forth or cyclic stressing of the fastener. Eventually, cracks form at the high stress points, and these cracks will progress to the point where the fastener can no longer support its designed load. At this point the fastener fails with varying consequences.

In order for the nut to properly load the bolt and prevent premature failure, a designated amount of torque must be applied. Proper torque, in addition to distributing the stresses applied to each fastener safely throughout the structure, will also reduce the possibility of the fastener loosening in service.

The correct torque to apply when tightening an assembly is based on many variables. The fastener is subjected to two stresses when it is tightened–torsion and tension. Tension is the desired stress, while torsion is the necessary evil caused by friction. A large percentage of applied torque is utilized to overcome this friction, so that only tension remains after tightening.

The recommended torque values provided in table 9-1 have been established for average dry, cadmium-plated nuts for both the fine and coarse thread series of nuts. Thread surface variations such as paint, lubrication, hardening, plating, thread distortion, etc., may alter these values considerably. The torque values must be followed unless the Maintenance Instructions Manual or Structural Repair Manual for the specific aircraft requires a specific torque for a given nut. Torque values vary slightly with manufacturers. When the torque values are included in a technical manual for a specific end item, be it aircraft or component, these values take precedence over the standard torque values provided in the *Structural Hardware Technical Manual,* NAVAIR 01-1A-8.

Separate torque tables and torquing considerations are provided in NAVAIR 01-1A-8 for the large variety of nuts, bolts, screws, etc., utilized in aircraft construction. The AMH supervising major assembly removal and installation should utilize this manual when specific torque values are not provided as a part of the removal/replacement instructions.

The following rules apply for correct use of table 9-1:

1. To obtain values in foot-pounds, divide inch-pound values by 12.
2. Do not lubricate nuts or bolts except for corrosion-resistant steel parts or where specifically instructed to do so.
3. Always tighten by rotating the nut first if possible. When space considerations make it necessary to tighten the fastener by rotating the bolthead, approach the high side of the indicated torque range. Do not exceed the maximum allowable torque value.

Table 9-1.–Recommended torque values (inch-pounds)

CAUTION

THE FOLLOWING TORQUE VALUES ARE DERIVED FROM OIL FREE CADMIUM PLATED THREADS.

	TORQUE LIMITS RECOMMENDED FOR INSTALLATION (BOLTS LOADED PRIMARILY IN SHEAR)		MAXIMUM ALLOWABLE TIGHTENING TORQUE LIMITS	
Tap Size	Tension type nuts MS20365 and AN310 (40,000 PSI in bolts)	Shear type nuts MS20364 and AN320 (24,000 PSI in bolts)	Nuts MS20365 and AN310 (90,000 PSI in bolts)	Nuts MS20364 and AN320 (54,000 PSI in bolts)
		FINE THREAD SERIES		
8-36	12-15	7-9	20	12
10-32	20-25	12-15	40	25
1/4-28	50-70	30-40	100	60
5/16-24	100-140	60-85	225	140
3/8-24	160-190	95-110	390	240
7/16-20	450-500	270-300	840	500
1/2-20	480-690	290-410	1100	660
9/16-18	800-1000	480-600	1600	960
5/8-18	1100-1300	600-780	2400	1400
3/4-16	2300-2500	1300-1500	5000	3000
7/8-14	2500-3000	1500-1800	7000	4200
1-14	3700-5500	2200-3300*	10,000	6000
1-1/8-12	5000-7000	3000-4200*	15,000	9000
1-1/4-12	9000-11,000	5400-6600*	25,000	15,000
		COARSE THREAD SERIES		
8-32	12-15	7-9	20	12
10-24	20-25	12-15	35	21
1/4-20	40-50	25-30	75	45
5/16-18	80-90	48-55	160	100
3/8-16	160-185	95-100	275	170
7/16-14	235-255	140-155	475	280
1/2-13	400-480	240-290	880	520
9/16-12	500-700	300-420	1100	650
5/8-11	700-900	420-540	1500	900
3/4-10	1150-1600	700-950	2500	1500
7/8-9	2200-3000	1300-1800	4600	2700

The above torque values may be used for all cadmium-plated steel nuts of the fine or coarse thread series which have approximately equal number of threads and equal face bearing areas.

***Estimated corresponding values.**

4. Maximum torque ranges should be used only when materials and surfaces being joined are of sufficient thickness, area, and strength to resist breaking, warping, or other damage.

5. For corrosion-resisting steel nuts, use the torque values given for shear-type nuts.

6. The use of any type of drive-end extension on a torque wrench (fig. 9-33) changes the dial reading required to obtain the actual values indicated in the torque range tables. When using a drive-end extension, the torque wrench reading must be computed using the following formula:

$$S = \frac{T \times L_a}{L_a + E_a}$$

S equals handle setting or reading
T equals torque applied at end of adapter
L_a equals length of handle in inches
E_a equals length of extension in inches

For example, if it is desired to exert 100 inch-pounds at the end of the wrench and extension, when L_a equals 12 inches and E_a equals 6 inches, it is possible to determine the handle setting by making the following calculation:

$$S = \frac{100 \times 12}{(12 + 6)}$$

$$S = \frac{1200}{18}$$

$$S = 66.6 \text{ inch-pounds}$$

Whenever possible, attach the extension in line with the torque wrench. When necessary to attach the extension at an angle to the torque wrench as shown in figure 9-33, the effective length of the assembly will be $L_a + E_b$ as shown in the figure. In this instance, length E_b must be substituted for length E_a in the formula.

NOTE: It is not advisable to use a handle extension on a flexible beam type torque wrench at any time. A handle extension alone has no effect on the reading of other types. The use of a drive-end extension on any type of torque wrench makes use of the formula necessary. When the formula has been used, force must be applied to the handle of the torque wrench at the point from which the measurements were taken. If this is not done, the torque obtained will be in error.

AIRFRAME AND CONTROL SURFACE ALIGNMENT

Alignment of the airframe structure is nothing more than the position relationship of each major component—the wing group, tail group, and fuselage group—to the other. The alignment of the airframe is important since it is directly related to the aerodynamic performance of the aircraft.

For this reason and for purposes of determining if any hidden structural failures exist, an alignment check should be performed when an aircraft has encountered excessive g's in flight, when a hard landing has been experienced, or when the aircraft has been subjected to extensive damage.

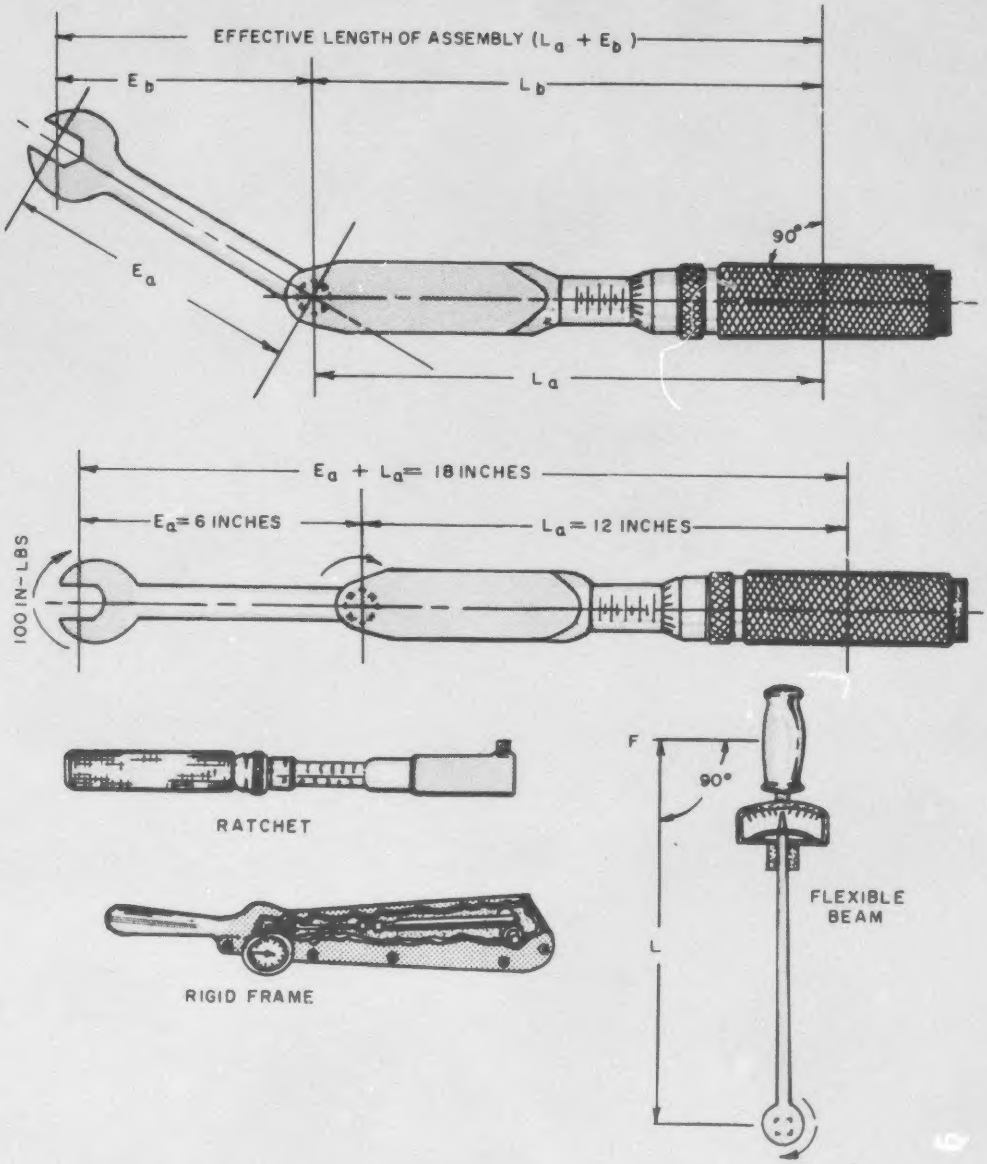
The need for an alignment check after extensive damage is rather apparent; however, this is not necessarily so in situations where aircraft exceeds the g design limit or where a hard landing has been experienced. The alignment check under these conditions may bring to light damage which might otherwise go unnoticed.

LEVELING METHODS

Prior to making an alignment check it is necessary to level the aircraft both laterally and longitudinally. This may be accomplished by using the transit, spirit level, or plumb bob and datum plate method.

When leveling an aircraft for alignment check, the aircraft should be inside a hangar where air currents will not interfere with the accuracy of the alignment readings. Jacks should be used to control the attitude of the aircraft during the check.

The method of leveling specified by the manufacturer in the applicable Structural Repair Manual should always be used.


EFFECTIVE LENGTH OF ASSEMBLY ($L_a + E_b$)
E_b
L_b
90°
E_a
L_a
$E_a + L_a$ = 18 INCHES
E_a = 6 INCHES
L_a = 12 INCHES
100 IN-LBS
RATCHET
RIGID FRAME
F
90°
L
FLEXIBLE BEAM

203.4.1

Figure 9-33.—Torque wrenches.

Transit

The transit method is preferred because of the accuracy which is obtained. Transit leveling is accomplished by sighting specified points on the fuselage and placing steel scales on the bottom edge of the forward trunnion pins. The points on the fuselage are for longitudinal leveling, and the scales are placed on the trunnion pins for lateral leveling. The scales and the points are sighted through a surveyor's transit. Figure 9-34 illustrates transit leveling an aircraft.

Spirit Level

Aircraft which use the spirit level method have leveling lugs either built into the structure or provisions for mounting them on the structure. The leveling lugs are usually in the nosewheel well. Spirit leveling provisions are illustrated in figure 9-35.

NOTE: The leveling lugs should be inspected for possible damage or misalignment prior to leveling the aircraft. In the event of damage to the leveling lugs, the repaired lugs must be calibrated by cross-reference with the transit leveling method.

Plumb Bob and Datum Plate

This method utilizes a datum plate or scale mounted on the deck of a compartment. Provisions for hanging the plumb bob are located directly above the datum plate. The aircraft is level when the plub bob pointer is at 0° on the datum plate. Figure 9-36 illustrates the plumb bob and datum plate method of aircraft leveling.

ALIGNMENT CHECK

The alignment or symmetry check is made after the aricraft has been leveled. This check is made by measuring the distance between certain points on the aircraft. These points are selected because they are relatively static and because their location will best reflect any misalignment. Most manufacturers recommend that the measurements be taken directly from one specified point to another. Figures 9-37(A) and 9-37(B) illustrate this type alignment check.

On other types of aircraft, drop points are provided at various locations for use in checking the alignment. Plumb bobs are dropped from each of these points to the reference plane (floor) so that the pattern for measurement may be described. When using this method, the elevation check dimensions are measured from the drop points to the reference plane, in this case the floor. The horizontal check dimensions are measured from one point (described by the plumb bob), along the reference plane (floor) to another point.

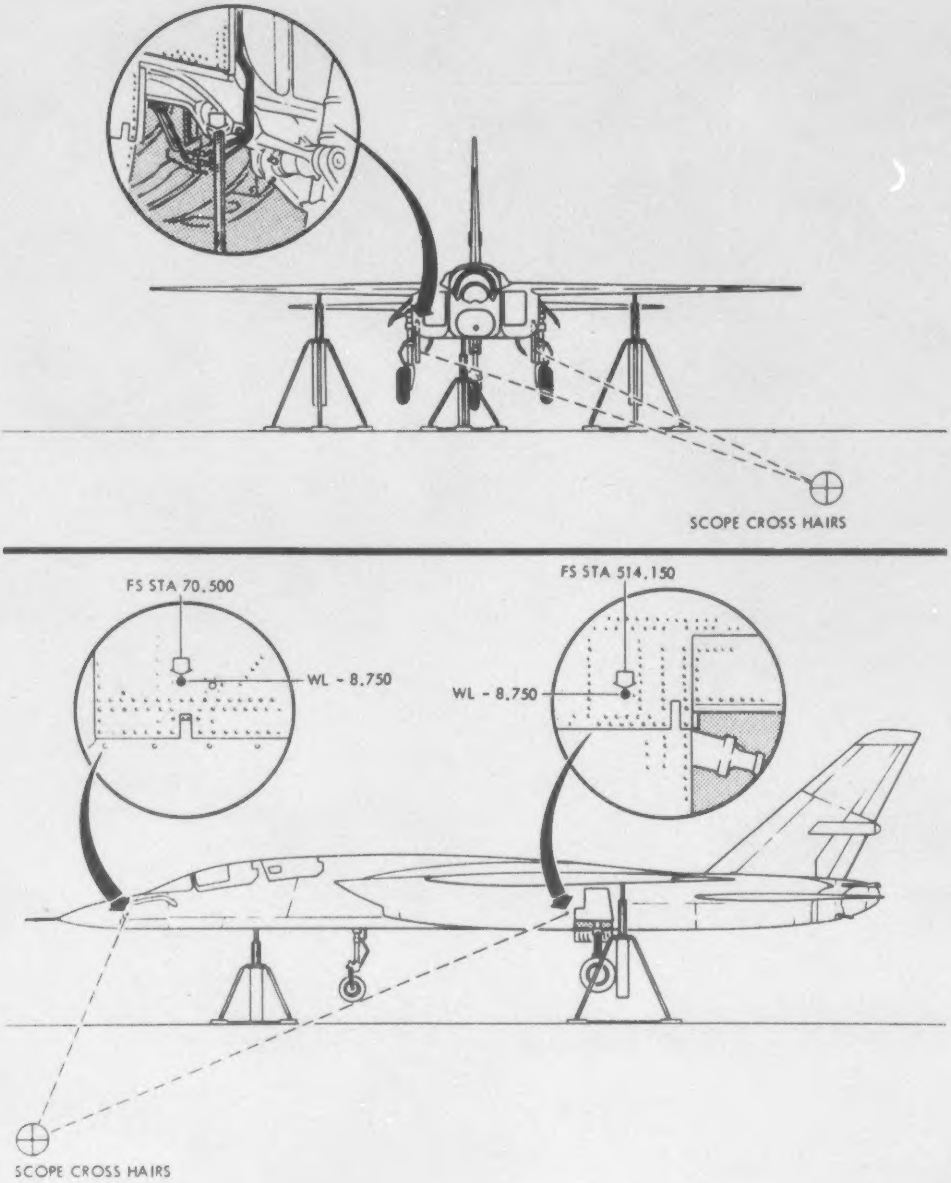
If the alignment check measurements exceed the tolerances listed in the aircraft Structural Repair Manual, the aircraft must be considered nonairworthy until a special disposition can be made by higher authority.

Wing Twist Check

With the aircraft leveled and the wings folded, it is possible to check the wings for twist. One checkpoint is provided on each wing. Clinometer readings taken at these points, when compared to the fuselage longitudinal clinometer readings, will enable the repairman to ascertain the condition of each wing. This is possible because there is a definite relationship between the fuselage longitudinal and wing reference lines. To perform a wing twist check, proceed as follows:

1. Fold wings and level aircraft laterally.
2. Install the leveling bar in the forward lockpin holes of the outboard panel fold rib.
3. Turn the rod until the milled flat at the forward end is straight up.
4. Set the clinometer on the "flat" and record the reading when the dial has stopped rotating.

The right- and left-hand wing readings must be within 0 degree, 12 minutes of each other for acceptable aerohynamic tolerances with respect to twist. They must also fall within the following upper and lower limits. The lower limit is established by subtracting 0 degree, 20 minutes from the longitudinal reading, the upper limit is established by adding 0 degree, 40 minutes to the longitudinal reading taken in the


SCOPE CROSS HAIRS
FS STA 70.500
WL - 8.750
FS STA 514.150
WL - 8.750
SCOPE CROSS HAIRS

216.177

Figure 9-34.–Transit leveling.

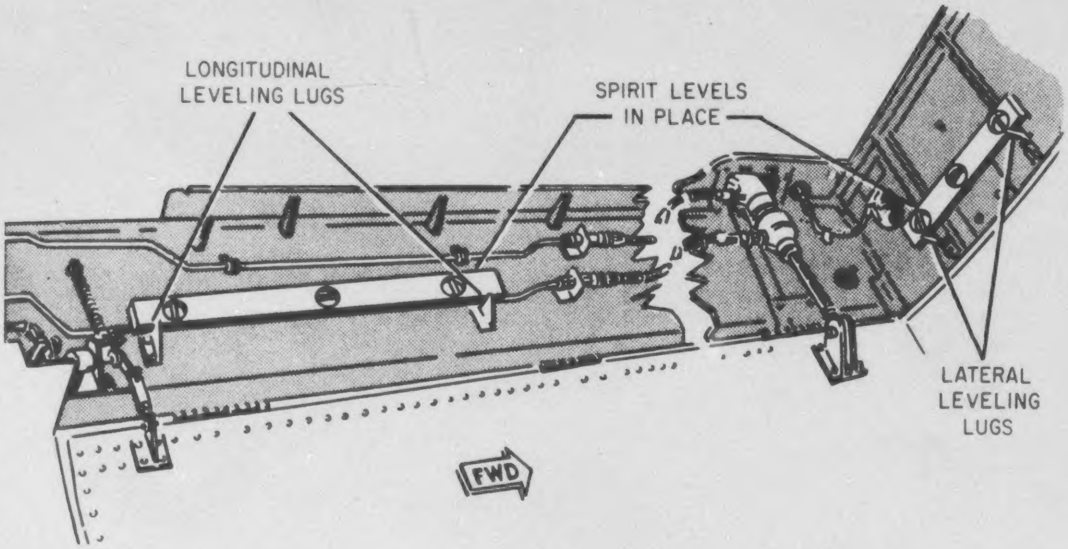
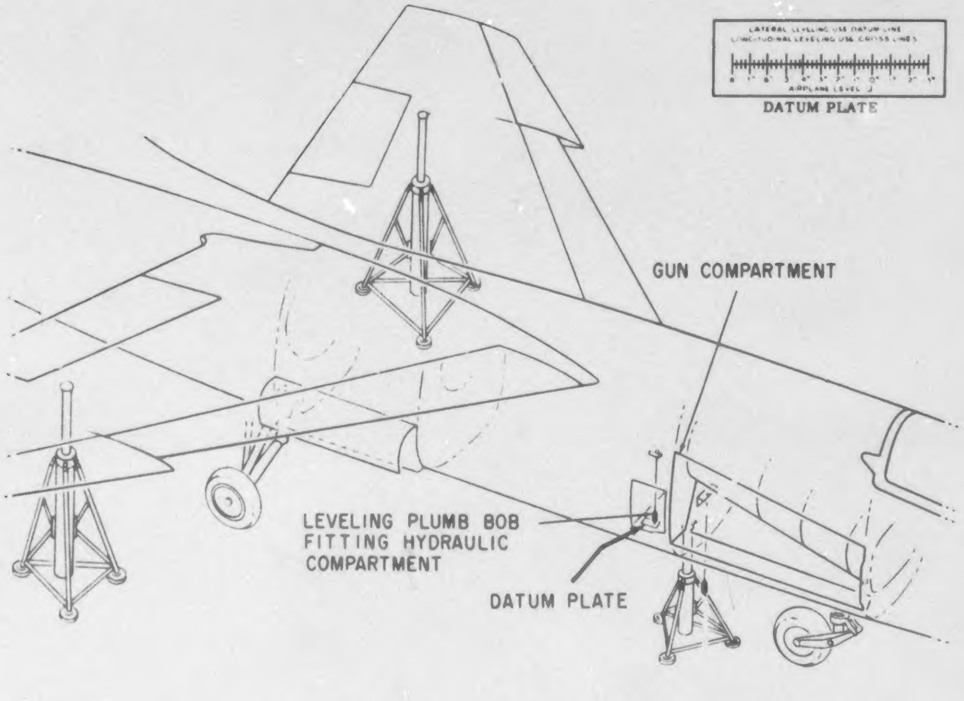

LONGITUDINAL LEVELING LUGS
SPIRIT LEVELS IN PLACE
LATERAL LEVELING LUGS
FWD

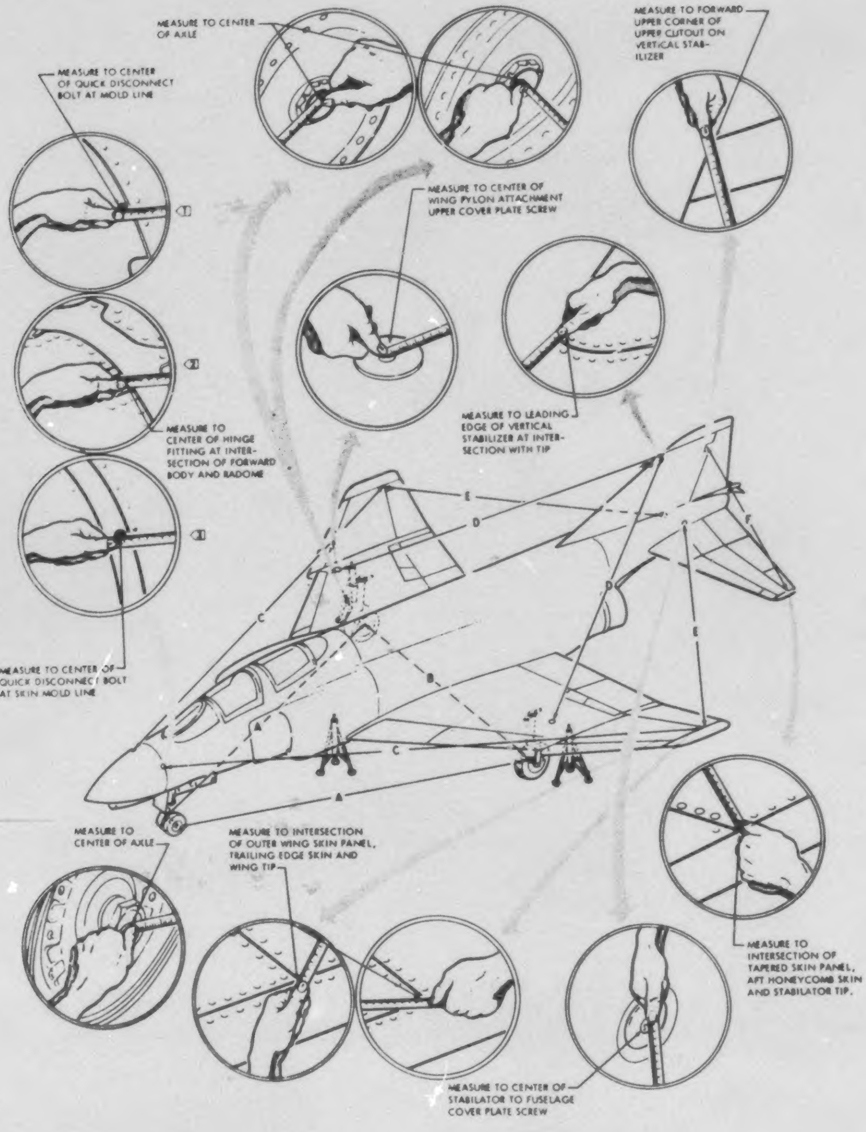
Figure 9-35.—Spirit leveling.

216.178


LATERAL LEVELING USE DATUM LINE
LONGITUDINAL LEVELING USE CROSS LINES
AIRPLANE LEVEL
DATUM PLATE
GUN COMPARTMENT
LEVELING PLUMB BOB FITTING HYDRAULIC COMPARTMENT
DATUM PLATE

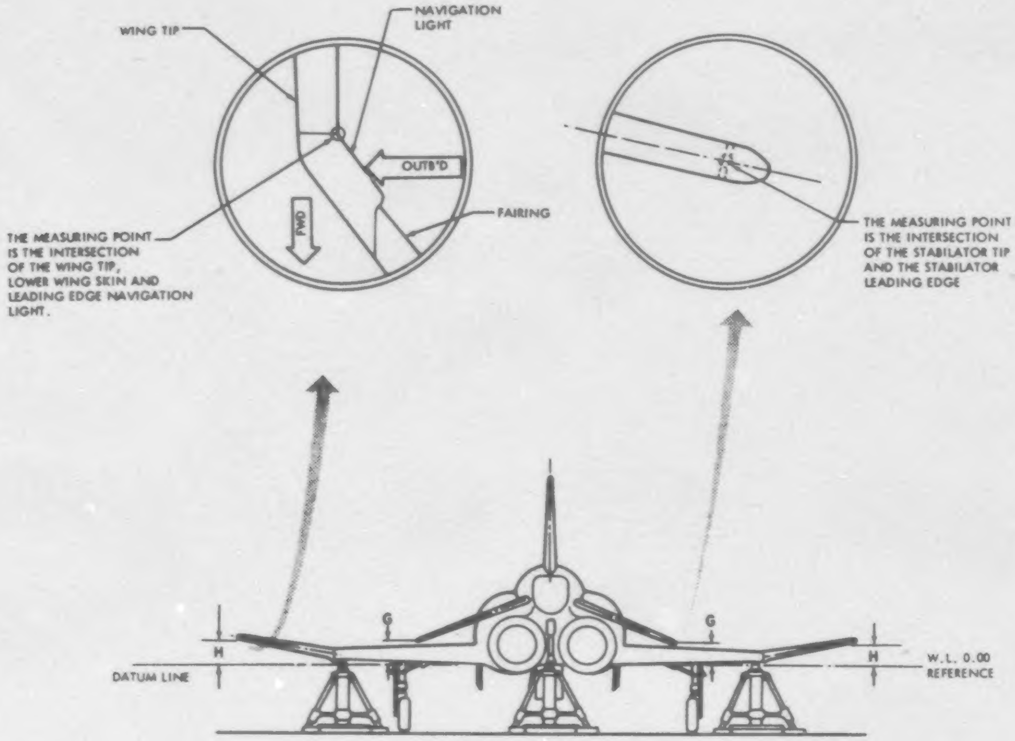
216.179

Figure 9-36.—Plum bob and datum plate leveling.


MEASURE TO CENTER OF AXLE
MEASURE TO FORWARD UPPER CORNER OF UPPER CUTOUT ON VERTICAL STABILIZER
MEASURE TO CENTER OF QUICK DISCONNECT BOLT AT MOLD LINE
MEASURE TO CENTER OF WING PYLON ATTACHMENT UPPER COVER PLATE SCREW
MEASURE TO LEADING EDGE OF VERTICAL STABILIZER AT INTERSECTION WITH TIP
MEASURE TO CENTER OF HINGE FITTING AT INTERSECTION OF FORWARD BODY AND RADOME
E
D
F
C
D
E
B
A
C
A
MEASURE TO CENTER OF QUICK DISCONNECT BOLT AT SKIN MOLD LINE
MEASURE TO CENTER OF AXLE
MEASURE TO INTERSECTION OF OUTER WING SKIN PANEL, TRAILING EDGE SKIN AND WING TIP
MEASURE TO INTERSECTION OF TAPERED SKIN PANEL, AFT HONEYCOMB SKIN AND STABILATOR TIP.
MEASURE TO CENTER OF STABILATOR TO FUSELAGE COVER PLATE SCREW

216.180

Figure 9-37A.—Aircraft alignment data.


WING TIP
NAVIGATION LIGHT
OUTB'D
FWD
FAIRING
THE MEASURING POINT IS THE INTERSECTION OF THE WING TIP, LOWER WING SKIN AND LEADING EDGE NAVIGATION LIGHT.
THE MEASURING POINT IS THE INTERSECTION OF THE STABILATOR TIP AND THE STABILATOR LEADING EDGE
G
G
H
H
DATUM LINE
W.L. 0.00 REFERENCE

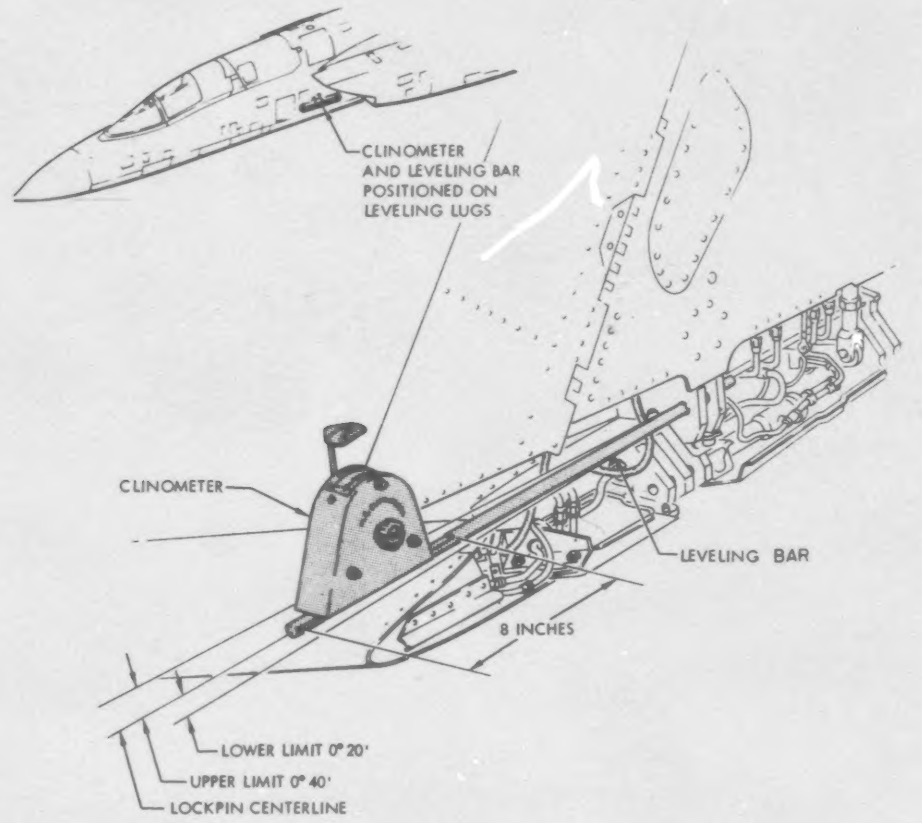
REF. LETTER	DIMENSIONS		DIMENSION TOLERANCE BETWEEN AIRCRAFT		DIMENSION TOLERANCE BETWEEN LEFT & RIGHT SIDE OF AIRCRAFT	
	INCHES	FEET & INCHES	INCHES	INCHES	INCHES	INCHES
A	294.00	24' 6"	± 0.75	± 3/4	0.75	3/4
B	206.46	17' 2 7/16"	± 1.00	± 1		
C	476.45	39' 8 7/16"	± 1.00	± 1	0.50	1/2
D	292.05	24' 4 1/16"	± 0.75	± 3/4	0.375	3/8
E	260.08	21' 8 1/16"	± 1.00	± 1	0.50	1/2
F	143.15	11' 11 1/8"	±0.50	± 1/2	0.375	3/8
G	17.403	1' 5 3/8"	± 0.375	± 3/8	0.375	3/8
H	19.66	1' 7 11/16"	± 0.375	± 3/8	0.375	3/8

216.181

Figure 9-37B.—Aircraft alignment data and measurement chart.

auxiliary wheel well. For example, if the longitudinal reading was 1 degree, 35 minutes, the lower limit would be 1 degree, 15 minutes, and the upper limit would be 2 degrees, 15 minutes.

Figure 9-38 illustrates a wing twist check on the RA-5C aircraft. The wing clinometer readings must fall within this range as well as within 0 degree, 12 minutes of each right-to-left-hand wing reading. This check, together with the steel tape measurements taken when the wings are spread, is a satisfactory check against wing bending and twist. If the clinometer readings and tape measurements are



216.182

Figure 9-38.–Alignment data-wing twist check.

not within the tolerances specified, the aircraft must be inspected on site by a depot level maintenance field investigation team or ferried to a depot maintenance facility for a complete investigation and final disposition.

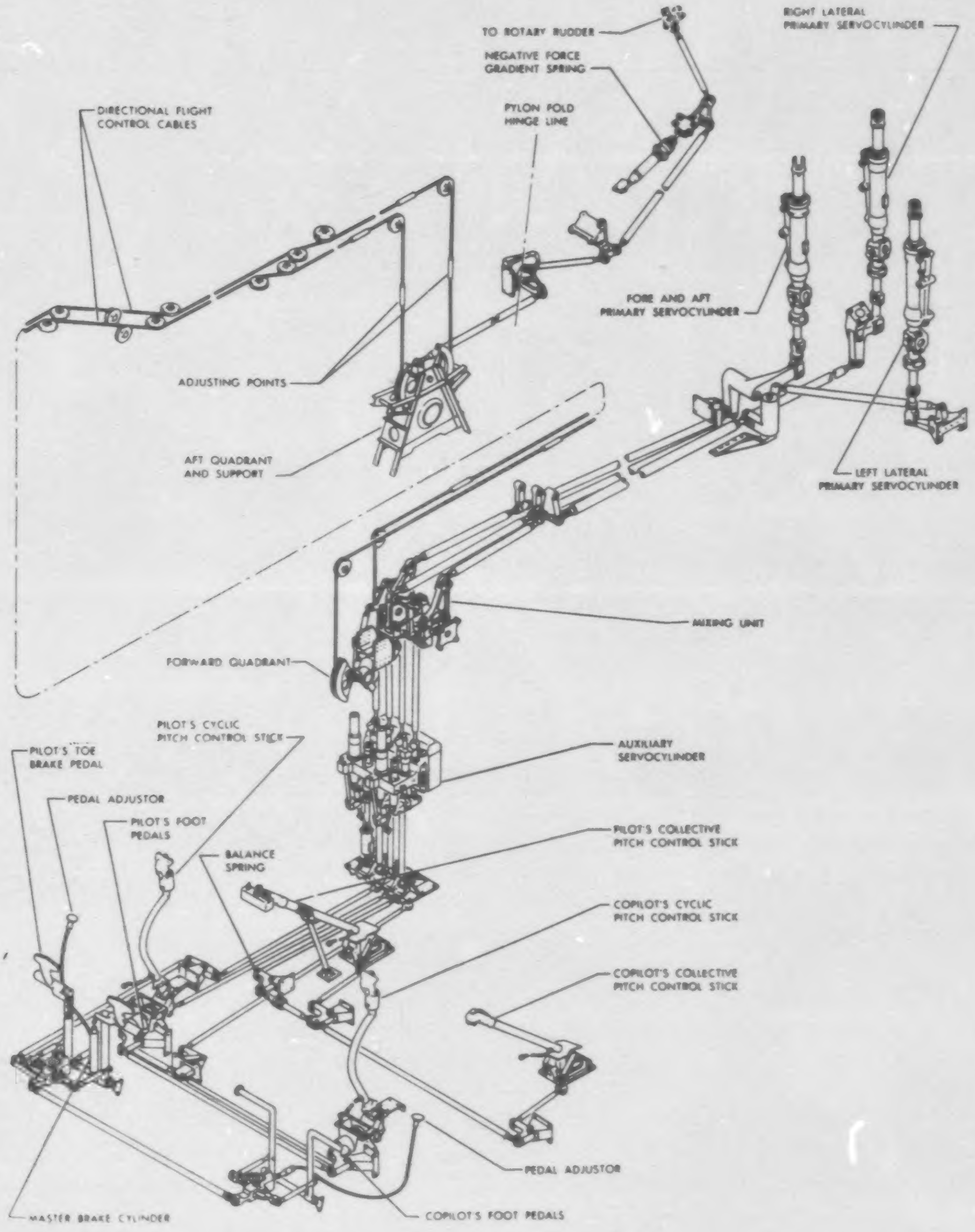
HELICOPTER FLIGHT CONTROL SYSTEMS

Information necessary for the AMH to be able to analyze flight control malfunctions and determine corrective actions to be complete, must necessarily include helicopter flight controls. The value of the helicopter in rescue work and as a combat assault platform has been firmly established. The necessity for an almost continuous state of flight readiness to provide immediate response to rescue and other mission requirements is dependent on reliable operation of essential flight controls.

In this section, the hydraulically powered flight control mechanism of the SH-3A, illustrated in figure 9-39, is covered to provide the reader with a representative example of the systems common to most helicopters.

ROTARY WING FLIGHT CONTROLS

The rotary wing flight controls consist of the cyclic and collective pitch control systems. The cylic pitch control system provides the means of controlling forward, aft, and lateral movement


TO ROTARY RUDDER
NEGATIVE FORCE GRADIENT SPRING
RIGHT LATERAL PRIMARY SERVOCYLINDER
DIRECTIONAL FLIGHT CONTROL CABLES
PYLON FOLD HINGE LINE
FORE AND AFT PRIMARY SERVOCYLINDER
ADJUSTING POINTS
AFT QUADRANT AND SUPPORT
LEFT LATERAL PRIMARY SERVOCYLINDER
MIXING UNIT
FORWARD QUADRANT
PILOT'S CYCLIC PITCH CONTROL STICK
PILOT'S TOE BRAKE PEDAL
AUXILIARY SERVOCYLINDER
PEDAL ADJUSTOR
PILOT'S FOOT PEDALS
BALANCE SPRING
PILOT'S COLLECTIVE PITCH CONTROL STICK
COPILOT'S CYCLIC PITCH CONTROL STICK
COPILOT'S COLLECTIVE PITCH CONTROL STICK
PEDAL ADJUSTOR
MASTER BRAKE CYLINDER
COPILOT'S FOOT PEDALS

216.183

Figure 9-39.—Flight control systems (SH-3A).

of the helicopter. The collective pitch control system provides vertical control of the helicopter.

Cyclic Pitch Control System

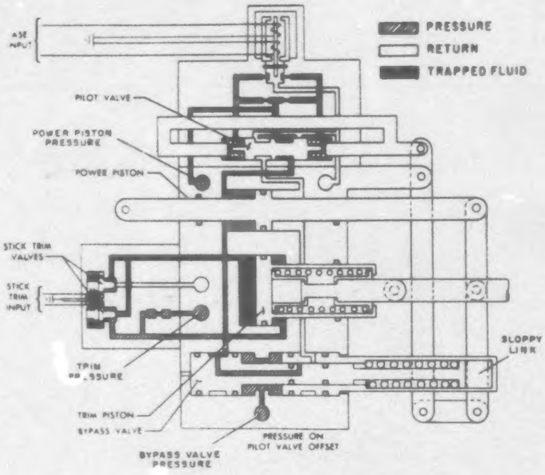
Movement of the pilot's or copilot's cyclic stick is transmitted through a series of control rods and bellcranks to the auxiliary servocylinders, mixing unit, and three primary servocylinders. These primary servocylinders control movement (attitude) of the rotary wing blades.

The cyclic system also incorporates a stick trim system which hydraulically operates the controls for automatic flight. During automatic flight, trim movements may be controlled manually by the cyclic stick grip switch or overriden for major control changes by stick movement.

Moving the cyclic stick forward retracts the fore-and-aft primary servocylinder. Aft movement extends the servocylinder. In both cases the helicopter will advance in the direction of stick movement. Movement of the stick laterally will move the helicopter right or left corresponding with stick movement by retracting and extending of the left and right lateral primary servocylinders.

Collective Pitch Control System

Movement of the collective pitch control stick is transmitted through a series of control rods and bellcranks to the appropriate bank of the auxiliary servocylinder, then to the mixing unit. At the mixing unit, all vertical movements of the collective sticks are transmitted to the primary servocylinders and the rotary wing swashplate where the pitch of all blades is increased or decreased equally and simultaneously. A balancing spring attached to the control rods helps to balance the weight of the collective stick. A friction lock on the pilot's collective stick applies the desired amount of friction to the tube of the collective stick to prevent creeping during flight and to provide feel for the pilot when operating the controls. The friction is applied by rotating the serrated handgrip on the collective stick to its stop.



216.184

Figure 9-40.–Auxiliary servocylinder.

The grip of each collective stick contains several switches which are labeled for the function they control. In the automatic stabilization equipment (ASE) mode operation, the collective pitch operation is controlled through the auxiliary servocylinder.

The following components of the rotary wing flight control systems are discussed to clarify their function.

AUXILIARY SERVOCYLINDER.–This cylinder consists of four separate banks of servomechanisms constructed as a unit. Figure 9-40 illustrates the fore-and-aft bank of the servocylinder. The other banks are similar in design and operation, except as noted in the following paragraphs.

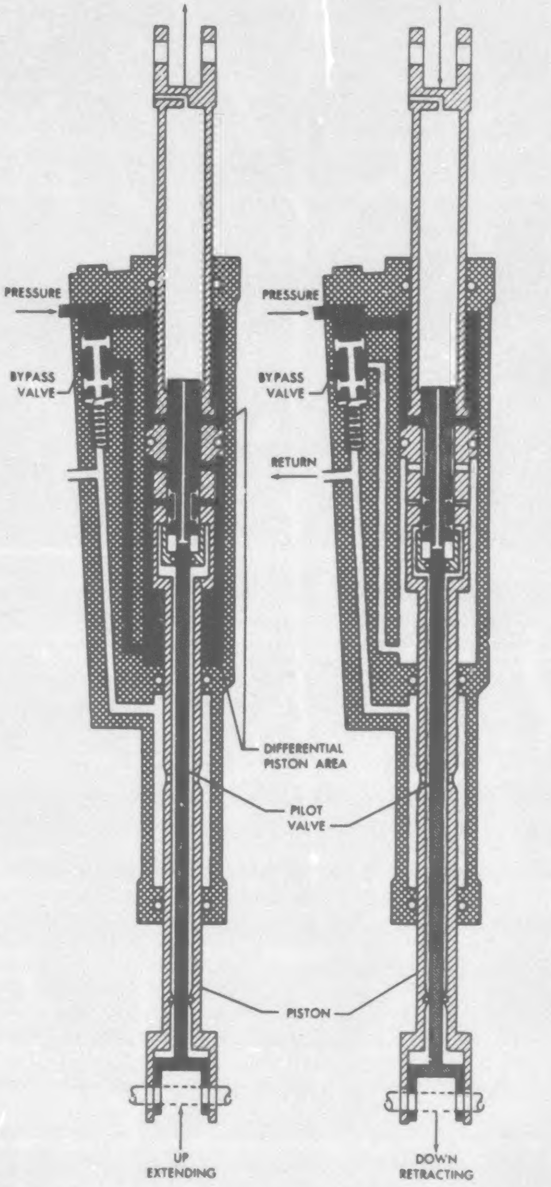
The power pistons of each bank transfer flight control movements mecahnicaily or assist them hydraulically before they are fed to the mixing unit. The cylinder operates on mechanical inputs during manual operation of the flight controls, on electrical inputs from the automatic stabilization equipment, and on electrical inputs from the stick trim system.

Each of the four banks operates in a single area of control functioning, providing fore-and-aft, lateral, collective, and directional hydraulic assists. Each bank incorporates a mechanical and electrical input hydraulic serve valve capable of displacing the pilot valve shuttle for ASE operation. The fore-and-aft and the lateral banks additionally incorporate a pair of solenoid-operated stick trim valves which control fore, aft, and lateral movements through the stick trim system.

The directional bank incorporates a pedal damping piston which restricts sudden heading changes. The auxiliary servocylinder operates at 1,500-psi hydraulic pressure supplied by the auxiliary hydraulic system.

MIXING UNIT.–The mixing unit, consisting of a system of bellcranks and linkage, coordinates and transfers independent movements of the lateral, forward, aft, and directional controls to the primary servocylinders and the rotary rudder. It also integrates collective pitch control movements with those of the lateral, fore-and-aft, and directional systems, causing the controls to move the three primary servocylinders simultaneously in the same direction, and to change the pitch on the rotary rudder blades to compensate for the change in pitch of the rotary wing blades.

PRIMARY SERVOCYLINDERS.–These three servocylinders transmit flight control movements to the stationary swashplate of the rotary wing head. If the primary hydraulic system is operating, the servocylinders hydraulically assist in flight control. If power is turned off or fails, they function only as control rods. (See fig. 9-41.) This is accomplished by the spring-loaded bypass valve, which prevents hydraulic lock and a "sloppy" link pilot valve connection. The pilot valve and the lower clevis of the power piston are connected to the flight control linkage by the same bolt. The close tolerance of the pilot valve connection causes the pilot valve to actuate before the loose fit at the power piston clevis is taken up and the power piston is mechanically displaced.



216.185

Figure 9-41.–Primary servocylinder.

Pressure entering the servocylinder upper port closes the bypass valve and enters the upper chamber. With the pilot valve in neutral, fluid cannot escape from the lower chamber and the piston remains motionless. If the pilot valve is moved upward, fluid is ported into the lower chamber, and the piston will rise due to a pressure area differential. If the pilot valve is moved down, the fluid in the lower chamber is ported to return, and the piston will be forced downward by upper chamber pressure.

When flight control movements stop, the piston will continue to move until the ports of the pilot valve close. The pilot valve clevis will be in the center of the sloppy link. When pressure is turned off, the bypass valve will open, preventing hydrualic lock.

SWASHPLATE.–The swashplate, illustrated in figure 9-42, transmits movement of the flight controls to the rotary wing blades. A ball ring and socket allows the swashplate to be tilted off its horizontal plane and move on its vertical axis.

The swashplate consists of a rotating swashplate, connected to the rotary wing hub by the rotating scissors and adjustable pitch control rods, and a stationary swashplate connected to the main gearbox by the stationary scissors and the primary servocylinders. Each swashplate is bolted together in a way that permits the rotating swashplate to rotate within the stationary swashplate. When the primary servocylinders are actuated by the flight controls, the stationary swashplate is moved with this movement being transmitted to the rotating swashplate. The rotating swashplate transmits movements, via the adjustable pitch control rods, to the horns of the sleeve spindle of the rotary blades, thus changing the angles of incidence of the blades.

ROTARY RUDDER FLIGHT CONTROL SYSTEM

The rotary rudder flight control system controls the pitch of the rotary rudder blades, which in turn control the heading of the helicopter. The system is controlled by the foot pedals through a series of control rods and bellcranks connected to the directional bank of the auxiliary servocylinder and the mixing unit. (See fig. 9-39.) At the mixing unit, a control rod operates the forward quadrant, which is connected by cable to the aft quadrant. A control rod from the rear quadrant connects to the control rods, bellcranks, and pitch control shaft in the rotary rudder tail gearbox. A hydraulic pedal damper is incorporated in the auxiliary servocylinder bank (directional) to prevent sudden movements of the control pedals from causing rapid changes in blade pitch which might cause damage to the helicopter. As on conventional aircraft, the rudder pedals are adjustable for different leg lengths. The rotary rudder system can be operated by manual inputs or automatically by inputs from the automatic stabilization equipment. There is no provision in the directional bank for trim inputs.

The negative force gradient spring (fig. 9-39) cancels feedback loads exerted by the rotary rudder during flight and when the auxiliary hydraulic system is off. During ground operations, with the rotary rudder stationary, it extends any pedal movement from neutral to the extreme of the moved direction, provided the auxiliary hydraulic system is off. When the rotary rudder is stationary, an initial force is required to move either pedal from its extreme position.

With the auxiliary hydraulic system on, the effect of the negative force gradient spring is zero.

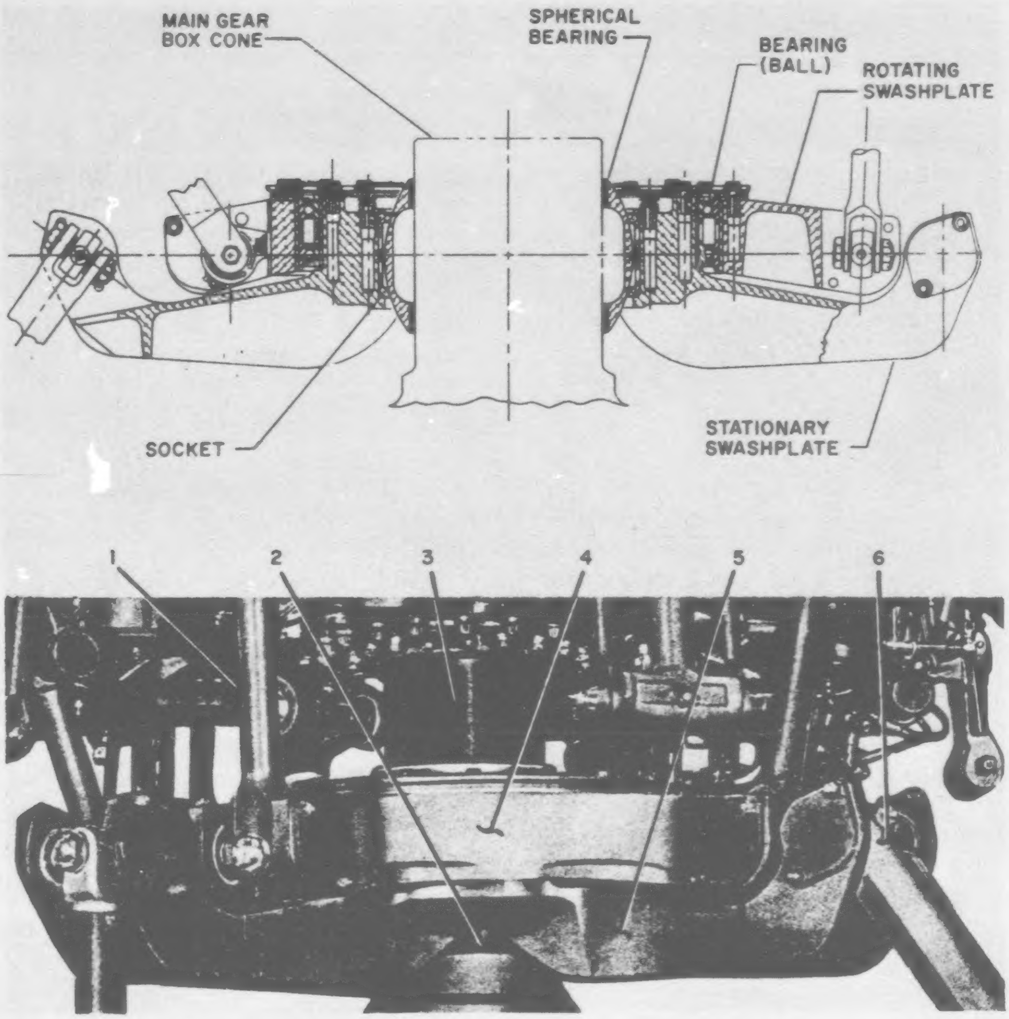
WARNING: The negative force gradient spring is preloaded to 600 pounds. To prevent injury to personnel and/or damage to flight controls, carefully follow maintenance instructions for removal, disassembly, assembly, and installation provided in the MIM.

ROTOR BRAKE SYSTEM

The rotor brake system permits application of the rotor brake manually or automatically as a part of the blade folding operation. The system is illustrated in figure 9-43 and consists of a master brake cylinder, pressure gage, panel package, rotor brake assembly, accumulator, check valves, and pressure switches. Automatic application is discussed with the automatic blade folding operation in chapter 10.

Rotor Brake

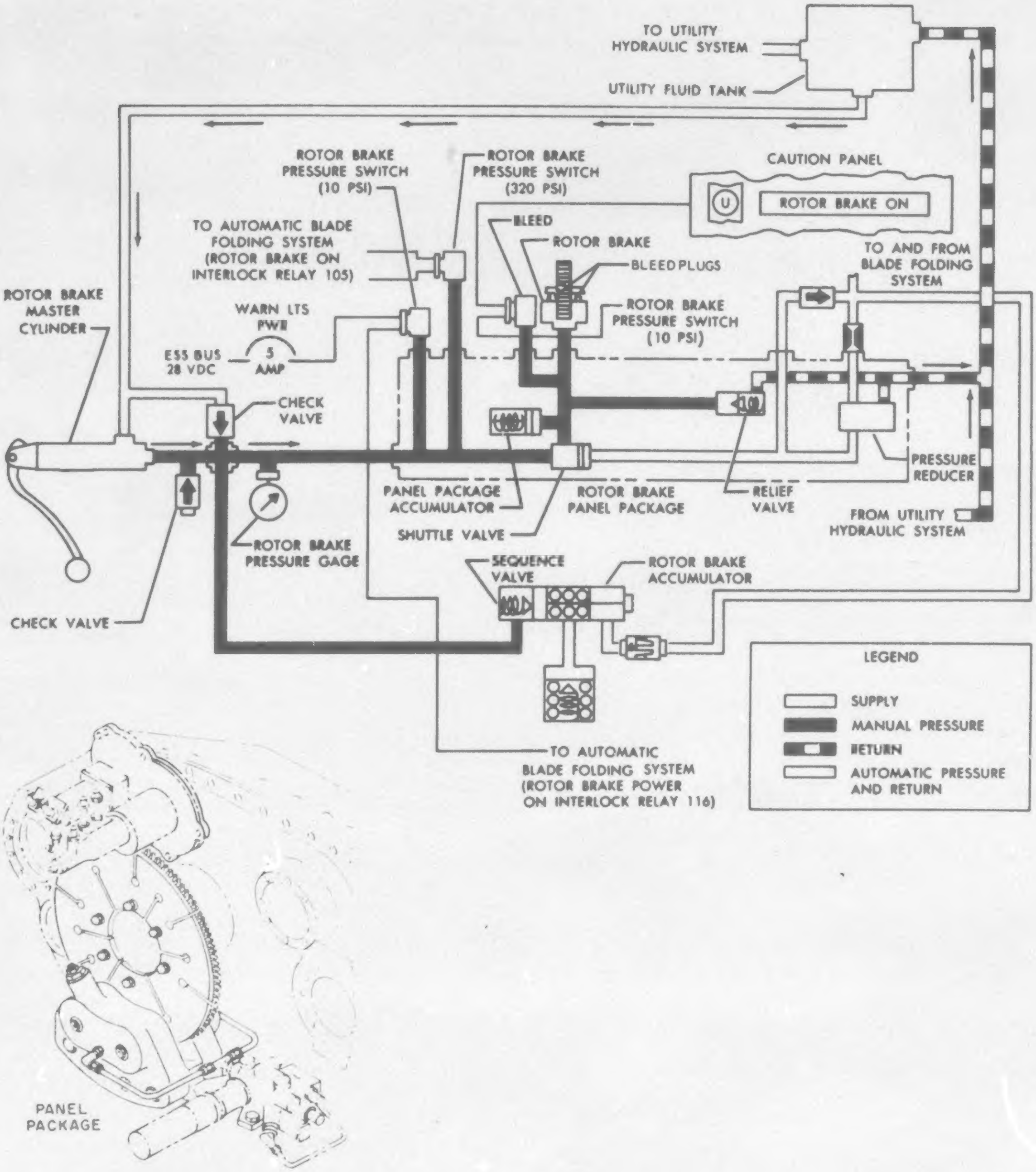
The rotor brake assembly is comparable to the single disc wheel brake in its design and operation. Hydraulic actuation of the brake is accomplished manually by using the rotorbrake master cylinder located in the cockpit, or


MAIN GEAR BOX CONE
SPHERICAL BEARING
BEARING (BALL)
ROTATING SWASHPLATE
SOCKET
STATIONARY SWASHPLATE
1
2
3
4
5
6

1. Adjustable pitch control rod.
2. Main gearbox.
3. Rotary wing shaft.
4. Rotating swashplate.
5. Stationary swashplate.
6. Stationary scissors.

216.186

Figure 9-42.—Swashplate—cross sectional and installed view.


TO UTILITY HYDRAULIC SYSTEM
UTILITY FLUID TANK
ROTOR BRAKE PRESSURE SWITCH (10 PSI)
ROTOR BRAKE PRESSURE SWITCH (320 PSI)
CAUTION PANEL
U
ROTOR BRAKE ON
TO AUTOMATIC BLADE FOLDING SYSTEM (ROTOR BRAKE ON INTERLOCK RELAY 105)
BLEED
ROTOR BRAKE
BLEED PLUGS
TO AND FROM BLADE FOLDING SYSTEM
ROTOR BRAKE MASTER CYLINDER
WARN LTS PWR
ESS BUS 28 VDC
5 AMP
ROTOR BRAKE PRESSURE SWITCH (10 PSI)
CHECK VALVE
PANEL PACKAGE ACCUMULATOR
ROTOR BRAKE PANEL PACKAGE
RELIEF VALVE
PRESSURE REDUCER
FROM UTILITY HYDRAULIC SYSTEM
SHUTTLE VALVE
ROTOR BRAKE PRESSURE GAGE
SEQUENCE VALVE
ROTOR BRAKE ACCUMULATOR
CHECK VALVE
TO AUTOMATIC BLADE FOLDING SYSTEM (ROTOR BRAKE POWER ON INTERLOCK RELAY 116)
LEGEND
SUPPLY
MANUAL PRESSURE
RETURN
AUTOMATIC PRESSURE AND RETURN
PANEL PACKAGE

216.187

Figure 9-43.–Rotor brake and system schematic.

automatically during the blade folding operation by the blade positioner control valve. (See fig. 10-17.) In manual operation, the brake is capable of stopping the rotary wing head in 14 seconds from 157 rpm. The brake linings must be replaced when any of the adjusting pins recede into the adjusting nut 1/8 inch. New lock screws and any other defective or worn parts supplied in the miscellaenous parts kit must be replaced as necessary each time linings are replaced.

Rotor Brake Panel Package

This package consists of an accumulator, relief valve, pressure reducer, and a shuttle valve. It receives hydraulic pressure from the master brake cylinder during manual operation and from the automatic blade folding system during automatic operation. When the master brake cylinder handle is in the off or detent position, the master cylinder is vented to the utility fluid tank. Movement of the master brake cylinder handle blocks the vent and builds up brake pressure. When the pressure increases beyond 200 psi, the shuttle valve in the panel package shifts to direct pressure to the rotor brake and block pressure from the automatic blade folding system. The panel package accumulator reduces pressure surges during manual and automatic operation, thus permitting a steady pressure to the brake. The relief valve will open to relieve pressure surges in excess of 600 psi that could not be handled by the accumulator.

Rotor Brake Accumulator

The spring-loaded rotor brake accumulator permits manual operation of the master cylinder handle during automatic blade folding operations. When the automatic brake is applied, the accumulator sequence valve is unseated, permitting actuation of the master cylinder handle by allowing hydraulic fluid to flow through the sequence valve and compress the accumulator spring. As the automatic brake is released, pressure is ported from the accumulator to the panel package shuttle valve and repositions it. Simultaneously, the panel package accumulator maintains hydraulic pressure, that was trapped from the automatic application, in the rotor brake. The rotor brake accumulator additionally compensates for thermal expansion and contraction of the fluid and aids in dampening pressure surges.

Rotor Brake Master Cylinder

The master cylinder is gravity fed by hydraulic fluid from the utility fluid tank. The brake handle is manually actuated down and forward to apply pressure to the system. A spring latch on the cylinder linkage automatically locks the handle in the on, or park, position. To release the brake, the latch must be pulled and the handle placed in the detent position. The pressure gage indicates the amount of pressure produced by the master brake cylinder. The check valve provides a means to pressure bleed the system. A minimum of 320-psi pressure is required to effectively operate the rotor brake.

MAINTENANCE

Organizational maintenance of the helicopter flight control system includes periodic inspection, lubrication, rigging and adjustment, cleaning of the rotary wing and rudder blades, and removal and replacement of malfunctioning components.

Maintenance of the auxiliary and primary servocylinders will generally be limited to minor adjustment and replacement of miscellaneous seals as specified in the Maintenance Instructions Manual and removal and installation of the complete component. Adjustments made on these servocylinders during overhaul are critical and should not be disturbed at the lower levels of maintenance.

Vibration of the rotary mechanisms can result in work hardening of metals and subsequent fatigue failure. Nondestructive testing of designated parts of the rotary wing and the rotary rudder at specified intervals is necessary to prevent failures. The auxiliary and primary servocylinders and the rotary wing head and rotary rudder assemblies are designated as high time removal items as listed in the Periodic Maintenance Requirements Manaul.

Cleaning of the rotary wing and rudder should be accomplished as necessary, using approved cleaners (listed in the MIM) mixed with water. The concentration of mixture will vary, depending on the surface condition. Waterless cleaner is used where water is not readily available.

WARNING: Both the rotary wing and rudder blades have areas that are joined by bonding adhesives. Never use solvents or cleaners not specifically authorized in the MIM, such as lacquer thinner, naphtha, carbon tetrachloride or other organic compounds for cleaning in these bonded areas. The bonding will be weakened by the solvent and may result in blade failure.

Rigging checks and adjustment involve coordinating the cyclic pitch control stick, collective pitch control stick, and foot pedal positions with the correct rotary wing and rotary rudder blade angles and ensuring that the flight controls are operating under normal friction loads.

The use of rigging pins and other rigging aids to provide proper rigging and subsequent proper operation is necessary. Each step outlined in the Maintenance Instructions Manual should be carefully performed.

Several quick rigging, cable adjustment, and operational checks with related maintenance precautions are covered in detail in the Maintenance Instructions Manual. No attempt to duplicate this information is provided in this chapter. The MIM must be consulted prior to any maintenance.

Proper rigging requires that instructions for the replacement of any component must have been strictly followed. Replacement of a bellcrank, support, or control rod will not generally require a rigging check provided the replacement control is the exact duplicate and/or length as the one it replaces.

At the completion of rigging, a flight test must be performed by a qualified pilot. A flight check chart is provided by the MIM, listing the conditions of the check, the required performance, and information to aid in the adjustment or correction of malfunctions experienced during the test flight.

ROTOR BLADE TRACKING

Blade tracking must be performed whenever the helicopter has been rerigged, or the blades, the main gearbox, or the main rotor head assembly have been replaced. Unless the blades are in proper track, vibrations will occur in the helicopter with every revolution of the main rotor. At high rpm settings these vibrations could cause serious structural damage.

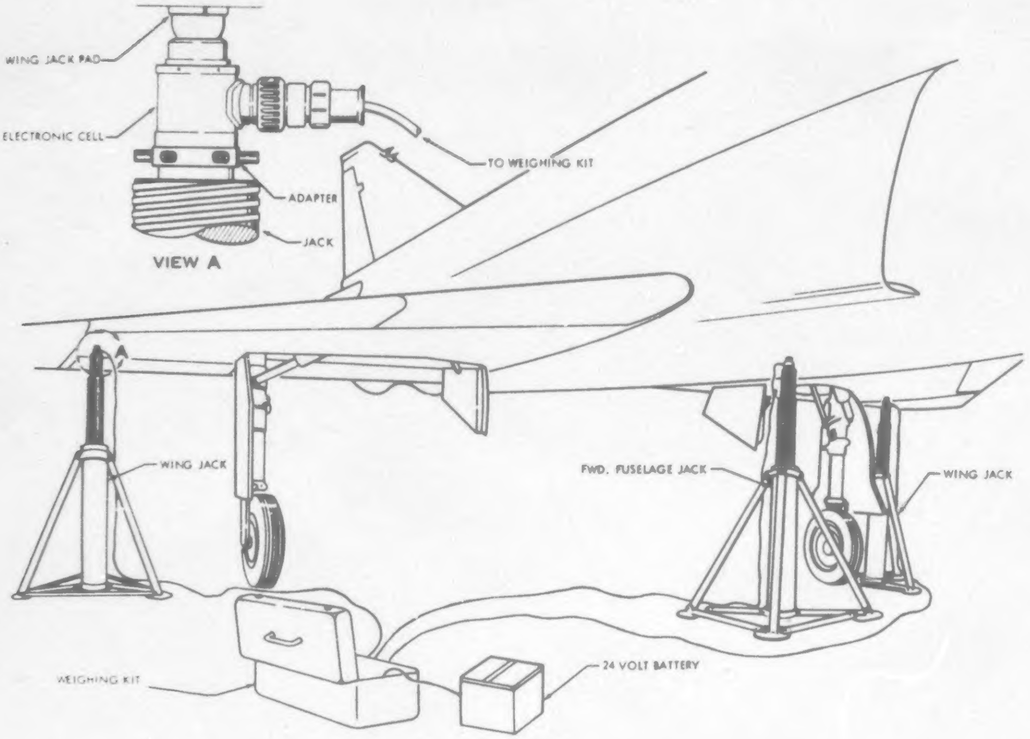
NOTE: The following information is provided to give the reader a general knowledge of the procedures used in tracking the main rotor blades of the SH-3A helicopter.

Tracking the blades is necessary to ensure that all of the blades rotate in the same horizontal plane (track). This is accomplished on the SH-3A by pretrack rigging of the rotary wing head and by the use of pretracked blades.

Pretrack rigging of the rotary wing head involves adjusting the pitch control rods until an exact sleeve angle, within 1 minute, is attained on all sleeve spindles. When this exact angle is established, a micrometer type decal is affixed on the adjustable pitch control rods as a permanent reference. A pretrack number is stenciled on each blade at manufacture or overhaul, based on the effective angle of the blade. Accordingly, any pretracked blade can be installed on the helicopter simply by setting the adjustable pitch control rod to the pretrack number stenciled on the blade.

Tracking Procedure

When tracking blades after installation, proceed as follows: With the rotary wing blades installed, set each adjustable pitch control rod to the pretrack number stenciled on the underside of the blade. If the pretrack number is MINUS, and the adjustable pitch control rod decal indicates that it is set at 0, loosen the locknut and shorten the rod by rotating the tang clockwise until it aligns with (closest notch to) the appropriate blade pretrack number on the lower scale of lower decal. Engage the tang by tightening the locknut. If the pretrack number of the blade is PLUS, and the adjustable pitch control rod decal indicates that it is set at 0, loosen the locknut and lengthen the rod by rotating the tang counterclockwise until it aligns



216.189

Figure 9-44.—Aircraft weighing.

with (closest notch to) the appropriate blade pretrack number on the upper scale of the lower decal. After adjusting the remainder of the pitch control rods, tighten the locknuts to 200- to 250-inch-pounds torque and safetywire the locknuts to the tang.

Next, a ground operational check must be performed. With the rotary wing head engaged, operate the engines at 100 percent and check for possible vibrations in the rotary wing head. If the blades are not in track, and the adjustable pitch control rods were properly set to the pretrack numbers on the blades, an alternate method of tracking the blades is available. In this case, an electronic blade tracker is used to check the blades under actual operating conditions to ensure that all blades are rotating in the same horizontal plane (track). Pitch adjustment of each blade can then be made, if necessary, to compensate for blade differences.

NOTE: Blades must not be adjusted for the electronic method of blade tracking unless problems are encountered in normal tracking procedures, and it has been decided that the pretrack rigging feature of the rotary wing head and blades will not be used.

AIRCRAFT WEIGHING

The manufacturer provides basic weight and balance data with each aircraft at delivery. This data is recorded in the *Handbook of Weight and Balance Data* (AN 01-1B-40). All subsequent changes which affect the basic weight and balance must be compiled and recorded in the *Handbook of Weight and Balance Data* according to instructions contained in this Handbook. This means that the aircraft must be weighed when major repairs or modifications are made, when unsatisfactory flight conditions are encountered (nose or tail heaviness), and as required by pertinent directives.

The aircraft should be weighed in its basic weight condition; that is, with fixed equipment which is actually present in the aircraft, less fuel and other expendable load items.

Weighing is usually accomplished with an electronic weighing kit similar to the one illustrated in figure 9-44.

The following is an aircraft weighing procedure:

1. Prepare the aircraft in accordance with the *Handbook of Weight and Balance Data.*
2. Place the aircraft in a hangar with the doors closed and all blowers in the immediate area turned off.
3. Place the proper jacks under the jack pads.
4. Place the electronic weighing cells on the jacks (using adapters if needed). (See fig. 9-44.)

NOTE: Zero the electronic cells in accordance with the manufacturer's recommendations.

5. Raise the jacks evenly until the aircraft is level, with the wheels off the deck.

NOTE: Jack the aircraft in accordance with the instructions in the applicable Maintenance Instructions Manual.

6. Level the aircraft, using the method recommended in the aircraft Structural Repair Manual or Maintenance Instructions Manual.
7. Take the weight readings with the aircraft in this condition.

NOTE: When using a battery-powered weighing kit, the battery must be fully charged or the readings will be erractic.

Figure 9-44 shows an aircraft prepared for weighing.

CHAPTER 10

ACTUATING SYSTEM MAINTENANCE

A variety of actuating systems is powered by the aircraft power and utility systems. Some receive power throughout the flight, while others are isolated from system pressure to prevent unnecessary loss of hydraulic fluid due to damage or system malfunction. Maintenance of these systems requires a working knowledge of system theory of operation, and function of various components. The ability to utilize system schematics and trouble analysis aids provided in the Maintenance Instructions Manuals is also necessary in order to accomplish successful trouble analysis using the deductive reasoning approach.

WING FOLD SYSTEMS

There are miscellaneous differences in the design and operating characteristics of the various hydraulically operated systems, and wing fold sysems are no exception. Basically similar components perform similar functions with only minor variation in part nomenclature and physical design.

The wing fold and spread systems described in the following paragraphs will point out some of these differences and discuss system operation and maintenance.

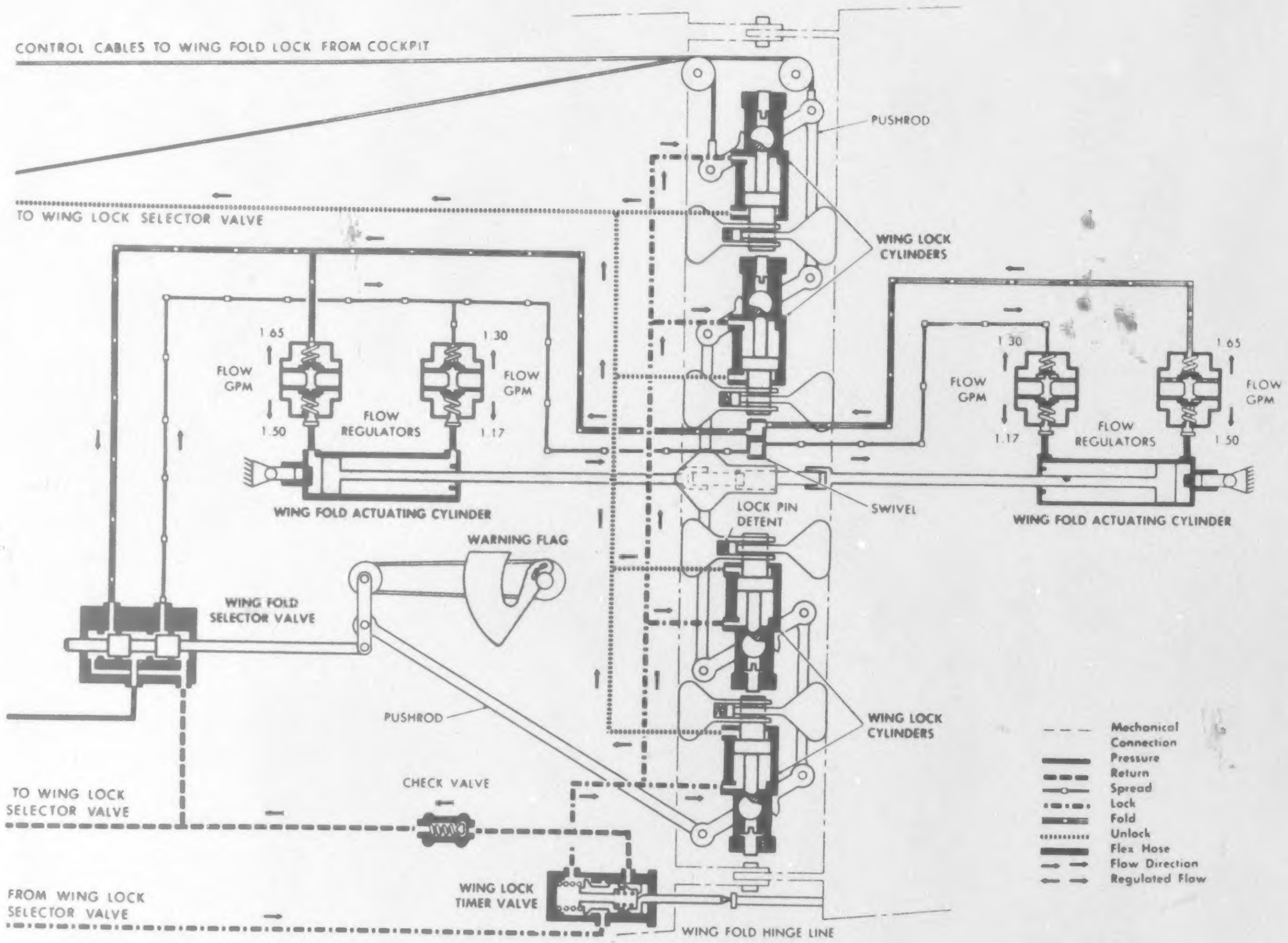
Figure 10-1 illustrates the wing fold system schematic of the A-6. Reference to this figure will aid in understanding the following paragraphs on system operation and component functions.

DESCRIPTION

The wings are folded and spread by the action of two opposing hydraulic actuating cylinders, located on each side of the wing fold joints, acting against a bellcrank. Power is supplied by the combined hydraulic power system, but the flight hydraulic system must also be pressurized to hold the combined system isolation valve in the open position, allowing hydraulic pressure to reach wing fold components.

Wing fold controls consist of a mechanical wing fold control handle and an electrical wing fold lockpin switch. To prevent inadvertent damage to control surfaces that cross the wing fold hinge line, a double-locking device is incorporated in the wing fold control handle and flight controls. When the control stick is not in neutral position, a mechanical interlock prevents the wing fold from being actuated. The wing fold handle, in turn, is actuated to position the mechanism on the lock cylinder, to allow retraction of the hydraulically operated wing lockpins.

The wing fold lockpin switch controls operation of the wing lock selector valve, which directs hydraulic pressure to the lockpins. However, when flaps and slats are extended, the electrical circuit is not complete and the switch is ineffective. When the wings are unlocked, the flap, slat, flaperon pop-up and wing tip speed brake circuits are opened, preventing operation of their solenoid-operated selector valves. When the wing fold control handle is not stowed, the control stick is restricted laterally, providing additional protection against damaging of surfaces. Manual operation of the wing lock selector valve on the ground bypasses these safety features and relies on the mechanic exercising caution.


CONTROL CABLES TO WING FOLD LOCK FROM COCKPIT
TO WING LOCK SELECTOR VALVE
PUSHROD
WING LOCK CYLINDERS
1.65
FLOW GPM
1.50
1.30
FLOW GPM
1.17
FLOW REGULATORS
WING FOLD ACTUATING CYLINDER
LOCK PIN DETENT
SWIVEL
1.30
FLOW GPM
1.17
1.65
FLOW GPM
1.50
FLOW REGULATORS
WING FOLD ACTUATING CYLINDER
WARNING FLAG
WING FOLD SELECTOR VALVE
PUSHROD
WING LOCK CYLINDERS
TO WING LOCK SELECTOR VALVE
CHECK VALVE
FROM WING LOCK SELECTOR VALVE
WING LOCK TIMER VALVE
WING FOLD HINGE LINE
Mechanical Connection
Pressure
Return
Spread
Lock
Fold
Unlock
Flex Hose
Flow Direction
Regulated Flow

216.190

Figure 10-1.–Wing fold and spread schematic (A-6, spread and locked condition).

OPERATION

The wings are unlocked by lifting the wing fold handle up and forward until it reaches the first stop. This operates the cable and pushrod mechanisms that control mechanical locking of the wing lock cylinders. This same action, through the pushrod connected to the mechanical locks, causes the warning flags to appear on top of the wings. Further movement of the wing fold handle at this point is prevented by a spring-loaded mechanical latch that blocks the crank at the wing lock cylinder.

With flight controls in the proper position and weight on the wheels, the wing fold lockpin switch is placed at UNLOCK. Power is supplied to the unlock side of the wing lock selector valve, allowing combined system utility hydraulic pressure to the four wing lock cylinders in each wing. Pressure in the wing lock cylinders moves the lock shaft to retract the wing lockpins. After completion of this action, the wing fold control handle can be moved to the full forward position, operating the wing fold selector valve in each wing and porting hydraulic pressure through flow regulators to the wing fold actuating cylinders, which extend and cause the wing to fold.

The wings are spread by moving the wing fold control handle aft to the first stop, mechanically positioning the wing fold selector valve in each wing to port hydraulic pressure through flow regulators to the wing fold cylinders, causing them to retract and spread the wings. The wing fold control handle is held at the first stop by the retracted lockpins, which prevent rotation of the lock shafts and cranks.

After spreading action, the wing fold lockpin switch is placed at LOCK and power is supplied to the lock side of the wing lock selector valve. The selector valve then ports hydraulic pressure to the closed timer valve in each wing fold joint. As spreading is completed, a spring-loaded lockpin detent in each inboard wing lock fitting is depressed by the outboard lock fitting. When the lock fittings are aligned, the lockpins can extend and enter the wing lock fittings. With lockpins extended, the lock shaft is free to rotate and the wing fold control handle can be moved flush with the top surface of the center console. This action rotates the lock shafts to prevent retraction of the lockpins and retracts the warning flags.

The flaps, slats, flaperon pop-up, and wing tip speed brake circuits are reactivated, and the lateral movement of the flight control system is restored to operation. When any lockpin fails to extend, the wing fold handle cannot be secured and the warning flaps will remain exposed.

COMPONENTS

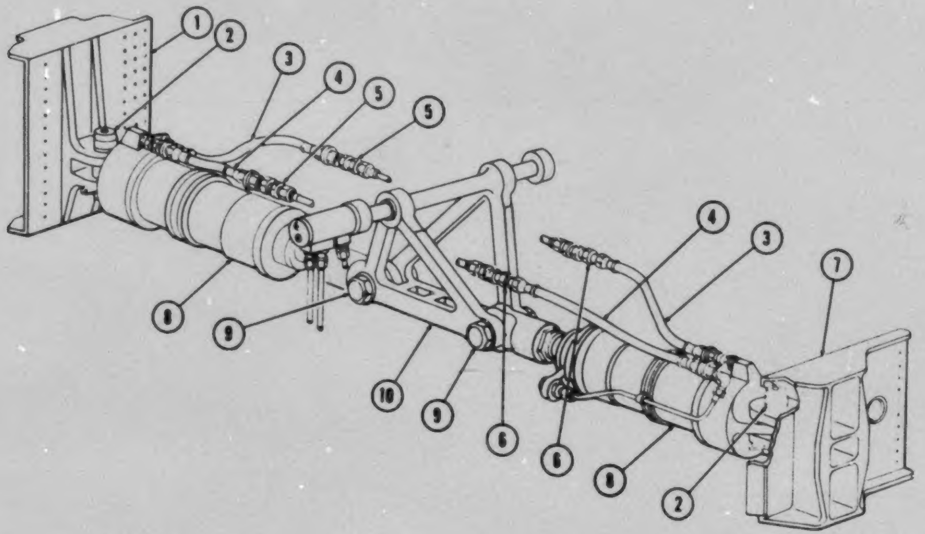
Wing Fold Cylinders

Figure 10-2 depicts the A-6 wing fold cylinders installation. The piston terminal ends are secured to the wing fold bellcrank located on the hinge line. The cylinder head ends are attached to the structure within the wing. The cylinders are accessible with the wings folded. To remove the head end attaching bolts, it is necessary to unscrew and remove the access plugs in the wing upper skin. A special spanner wrench is provided to remove and install these bolts.

Each cylinder has a dashpot feature installed on both ends to dampen the final movement on extension and retraction. An inspection hole is located in each terminal assembly to ensure the piston rod is properly screwed into the terminal. Two lubrication holes are provided in each rod end fitting to moisten the felt wiper ring with hydraulic fluid.

To fold the wings, pressure is ported to the extending end of the cylinder, acts upon the piston, and moves it outward. As the piston reaches the extended position, return fluid leaving the cylinder is forced through a small gap and acts as a damper to restrict piston extension and snub the wings as they reach the full folded position.

To spread the wings, pressure is ported to the retracting end of the actuating cylinder and passes through the small gap until piston movement allows normal fluid flow. Return fluid leaving the cylinder is restricted by a check valve and passes between the dashpot and piston shaft, snubbing the wings as they reach the spread position.



1. Wing fold cylinder inner support fitting.
2. Cylinder head end bolts.
3. Wing fold line.
4. Wing spread line.
5. Bulkhead unions (wing inner panel).
6. Bulkhead unions (wing outer panel).
7. Wing fold cylinder outer support fitting.
8. Wing fold cylinders.
9. Cylinder rod end bolts.
10. Fold bellcrank.
11. Cylinder swivels.

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Figure 10-2.—Wing fold actuating cylinders.

Selector Valves

The wing lock selector valve is located aft of the boarding ladder hinge and is accessible for manual actuation through the door marked Wing Lock Manual Control. The valve is a solenoid-operated slide valve, controlled by the wing fold lockpin switch. The valve ports hydraulic fluid to the wing lock cylinders during fold and spread operations. Manually operated pushbuttons are provided on the valve to unlock and lock the wings without electrical power. Maintenance personnel must keep in mind that this bypasses the safety features to prevent fold or spread operations when surfaces are not retracted or in neutral.

A wing fold selector valve is located inboard of the forward wing lock cylinder, at the forward area of the fold joint in each wing. They are accessible with the wings folded. The selector valves are manually operated slide valves, controlled by movement of the wing fold control handle. Positioning the wing fold control handle forward causes the valve spool to move inward and port hydraulic pressure to fold the wings. Moving the control handle back to the first stop positions the valve spool porting fluid to spread the wings. The valve spool is grooved to accept a 3/32-inch neutral rig pin, used when performing system rigging procedures.

Lock Cylinders

Four wing lock cylinders are mounted in the wing fold joint of each wing, located at each of the four wing lock fittings on the center panel. The locks are accessible when the wings are folded or after the hinged fairing doors on the underside of the wing center panel are opened. The forward locking cylinder is illustrated in figure 10-3.

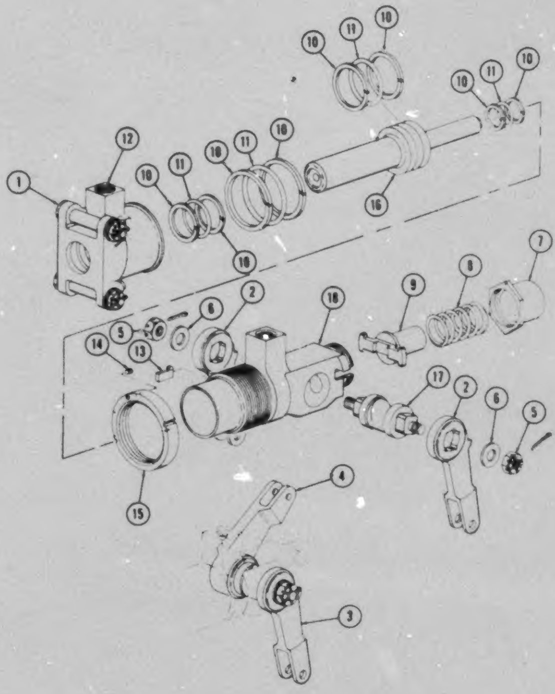
When the wings are spread and the wing center and outer panel lockpin fittings are aligned, the lockpin (cylinder piston) is moved into the lock fitting holes, preventing inadvertent wing folding. The lock cylinders incorporate the lock mechanism and its operating cranks and the spring-loaded mechanical latch (item 9, figure 10-3) that synchronizes the wing fold control handle operations with the lock plunger position.

A special wing fold lockpin driving tool is available to be used if any of the lockpins jam in the locked position, preventing wing folding. When this occurs, the wing fold control handle cannot be moved forward of the first stop. The lockpin must retract to remove the spring-loaded mechanical latch from the path of the crank. With the wing fold hinge line fairing doors open, the special tool can be inserted into the wing lock fitting to drive the lockpin out until it retracts. During this operation the wing fold control handle should be as far forward as it will go without forcing it. The wing fold lockpin switch should be in the UNLOCK position. All wing locks are then pressurized to the unlocked position and will normally retract.

Miscellaneous Hardware

Eight flow regulators are installed in the wing fold system, one in each of the spread and fold lines going to the wing fold actuating cylinders. The regulators control the speed of operation of the cylinders during the spread and folding operations. Drilled passages through the sleeve and pin of the regulator ensures some fluid flow in the event the regulator fails.

During wing spread operation, wing lock timer valves restrict fluid flow entering the wing lock cylinders, thus preventing the lockpins from moving until the lock fittings are properly aligned. The last 1/16 inch of spread motion depresses the valve plunger, moving the valve seat inward, closing the return port, and unseating the valve poppet. Hydraulic fluid is then routed through the cylinder port, locking the wing in the spread position.



1. Cylinder attaching crank.
2. Lock-lock crank.
3. Lock-lock crank.
4. Output crank.
5. Crank attaching nut.
6. Retainer.
7. Spring retainer.
8. Latch spring.
9. Crank locking latch.
10. Backup ring.
11. O-ring.
12. End fitting.
13. Locking key.
14. Setscrew.
15. Locking nut.
16. Piston.
17. Piston lock (lock-lock).
18. Cylinder body.

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Figure 10-3.—Forward wing lock cylinder.

Two wing fold cylinder swivels are installed in the wing fold system, one on each wing fold joint at the forward pivot point of the wing fold actuating cylinder bellcrank (item 11, fig. 10-2). The swivels provide a movable connection between the two wing fold cylinders' hydraulic lines during fold and spread operations.

A thermal relief valve is installed in the pressure line of the wing fold and wing lock selector valves. It vents excessive pressure buildup due to the thermal expansion of trapped fluid into the combined system return lines. When pressure increases above 3,730 to 3,830 psi the spring-loaded ball check unseats, and the valve relieves excessive pressure. The spring-loaded ball check reseats when pressure falls to 3,360.

MAINTENANCE

Maintenance of the wing fold system at the organizational level consists mainly of scheduled inspections, lubrication, rigging of mechanical linkages, removal and installation of components, and analysis of system malfunctions.

The Maintenance Instructions Manuals provide system schematics and trouble analysis sheets to assist in pinpointing causes of malfunctions. A thorough knowledge of the system prior to troubleshooting is a necessary requisite. Deductive, logical reasoning plus a systematic operational checkout of the system will inevitably produce more expedient results than trial and error troubleshooting methods.

Lack of lubrication or other required maintenance at prescribed intervals will generally be reflected by stiff, hard-to-operate wing fold control mechanisms or related wing fold discrepancies. Strict compliance with maintenance requirements in all cases will eliminate or miminize this possibility. All corrective maintenance should be in accordance with the instructions provided in the appropriate Maintenance Instructions Manual.

Wing lock warning flags rarely get out of adjustment, and whenever they fail to retract it should be considered an indication of failure of all locks to properly enter lock fittings. Realignment to provide a wing-lock indication without ensuring that the wings are positively locked certainly does not correct the discrepancy and presents an extremely hazardous flight condition.

Good maintenance practices, strict quality assurance by qualified inspectors, and the elimination of arm chair type supervision will ensure safe, timely, and quality corrective maintenance actions.

Intermediate maintenance of wing fold hydraulic components generally consists of installing cure date repair kits (sealing devices, etc.) and/or replacement of miscellaneous parts available as Fleet type repair kits. Parts in the repair kit are normally easy-to-replace items, which do not require the depth of disassembly and inspection necessary at complete overhaul, and are replaced whenever high time removal of a component is necessary. Information on repair kits for various components is provided in the applicable Illustrated Parts Breakdowns and, in some cases, the intermediate maintenance section of the Maintenance Instructions Manual and appropriate Overhaul and Repair (03) Manuals.

Step-by-step procedures for the repair of components are provided in the intermediate maintenance section of some Maintenance Instructions Manuals and/or 03 manuals. In general, repairs will consist of cleaning, disassembly, inspection, reassembly, and testing.

Inspection of disassembled components includes checking for visible damage to internal parts, thread damage, condition of plating, wear limitations, springs for distortion and return to specified free length, corrosion, and in some cases, nondestructive inspection of critical parts to detect discontinuities, fatigue cracks, etc.

Reassembly will normally be in the reverse order of disassembly and will include proper installation of parts, seals, packings, and retainers, and torquing, safety wiring, and cotter keying as applicable. Test of the component following repair will further verify its ability to perform its intended function and will generally consist of proof testing, static leak testing, and operational testing.

Throughout the complete intermediate level repair operation, the components undergoing repair must be subjected to quality assurance verification of specified repair steps as indicated in the applicable Maintenance Instructions Manual or Overhaul and Repair (03) Manual. It is NOT sufficient to eliminate the progressive quality assurance and verify the operation of the end product.

Stationary test benches utilized for testing hydraulic components are filled with MIL-H-6083 preservative hydraulic fluid vice MIL-H-5606 hydraulic fluid. Repaired components that are not to be installed immediately are drip drained; then all openings are capped or plugged to prevent the entrance of contaminants. Plastic plugs are prohibited because of the possibility of plastic chips entering the component and damaging seals or blocking critical passages.

The manhours expended in correcting malfunctions are documented on a VIDS/MAF. When a part is removed and is to be processed through the IMA for repairs, an additional five-part VIDS/MAF is initiated with the appropriate information filled in and attached to the component for turn-in. Consult the appropriate manuals for proper documentation of the VIDS/MAF. The job is not considered complete until the necessary paperwork has been completed, screened, and turned-in.

WING FOLD WITH AUTOMATIC JURY STRUT SYSTEM

The wing fold system of the C-2 and E-2 aircraft incorporates an automatic jury strut feature unique from other aircraft.

Description/Operation

Figure 10-4 illustrates the schematic diagram of the wing fold and jury strut system for one wing of the C-2. The system uses power from the combined hydraulic power system. Sequencing of events in the fold and spread cycles is controlled by mechanically operated timer valves, check valves, priority valves, lock valves, and flow regulators. The selector valve is electrically or manually controlled. Prior to selection of wing fold, the flaps must be at the 20° position. In an emergency the wings can be folded when the flaps are not at the 20° position, but damage can be expected to the wing trailing edge and the flaps.

Electrical control of the selector valve from the cockpit is provided by the wing fold control switch which is actuated by the wing fold control lever. Cockpit control requires both electrical and hydraulic power.

Manual control of the selector valve is possible at the combined system ground service panel and requires hydraulic power to fold the wings. Spreading the wings requires both electrical and hydraulic power.

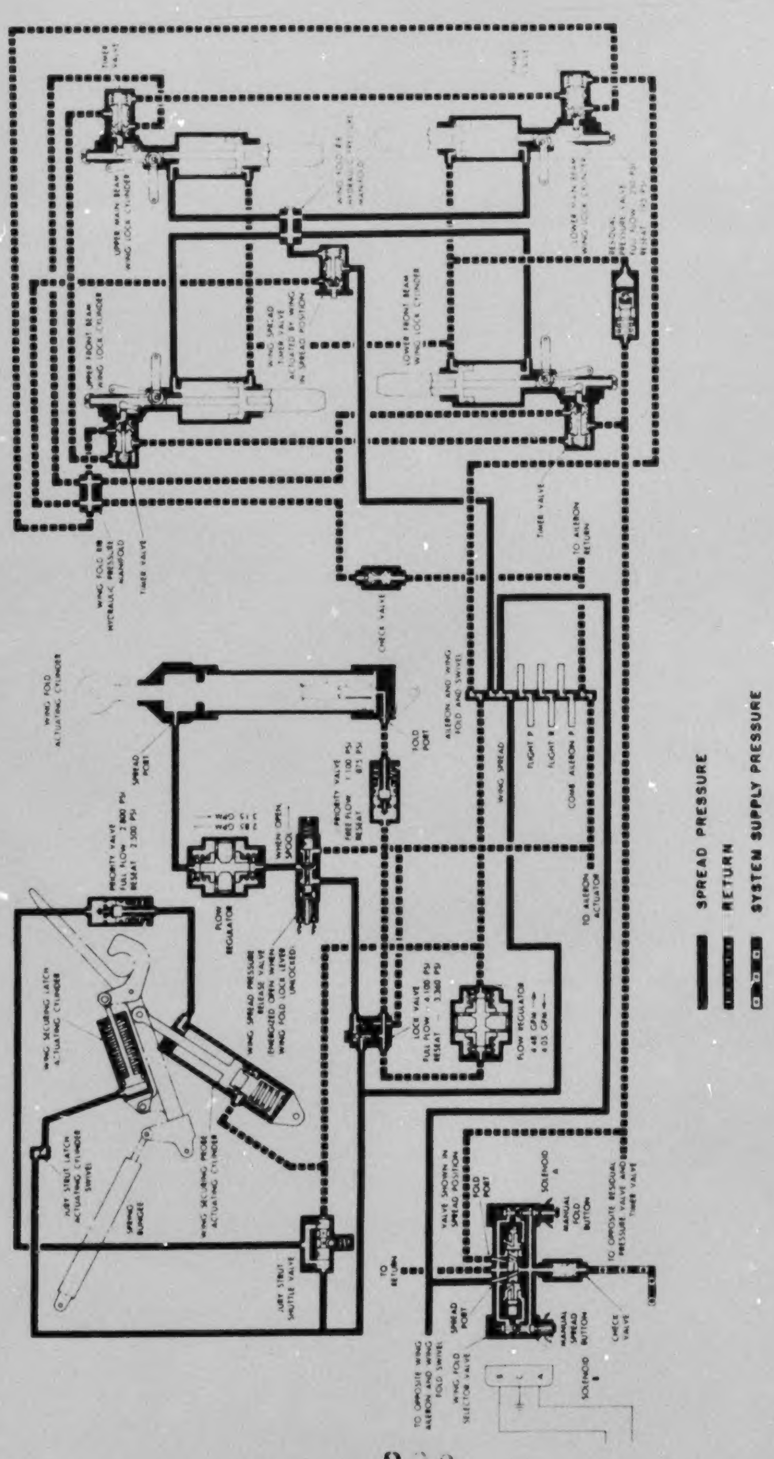
A wing lock mechanism and four wing lock cylinders on each wing fold joint lock the wing outer panels when they are in the spread position. Wing fold warning flags are extended whenever the wing lock-lock mechanism is unlocked to indicate an unlocked/unsafe wing condition. When folded, both wing outer panels are locked to probes on the outboard fins of the vertical tail by an automatic jury strut located in the wing panels.

In operation, with aircraft weight on the landing gear and flaps at the 20° position, power is supplied through various switches, circuits, and relays and is available to the wing fold control lever switch. Moving the wing fold lock lever to the unlocked position closes a lock lever limit switch and directs power to the left and right wing spread pressure release valve solenoids. When the wing fold lock lever is unlocked, cables connected between the lock lever and the locking mechanism at the wing fold joints actuate the mechanism to remove the mechanical interference from the wing lock cylinder tail shafts and raise the warning flags on top of the engine nacelle.

Moving the wing fold control lever to the FOLD or SPREAD position actuates the control switch to direct electrical power to the fold or spread solenoids of the selector valve.

Lock-lock safety latches, mounted on the main beam upper wing lock cylinders, mechanically lock the wing lock-lock mechanism in the unlocked position when the wings are folded. The safety latches prevent moving of the wing fold lock lever to the locked position until the wings are fully spread. When the wings are spread, a striker plate on the wing outer panel depresses the top portion of the safety latch and removes the mechanical interference.

During folding operations, the selector valve opens a return line for the wing lock cylinders and the wing fold actuating cylinders and directs hydraulic pressure through the residual pressure valves to the unlock ports of the wing lock cylinders, and to the timer valve on the front beam lower lock cylinder. The wing lock cylinders retract, and the tail shaft of the cylinder actuates the timer valve, allowing pressure to be directed through the timer valves, the aileron and wing fold swivel, flow regulator, lock valve, and the priority valve to the wing


SPREAD PRESSURE
RETURN
SYSTEM SUPPLY PRESSURE
CHECK VALVE
FLOW REGULATOR
WING FOLD ACTUATING CYLINDER
TIMER VALVE
JURY STRUT SHUTTLE VALVE
WING FOLD SELECTOR VALVE

216.194

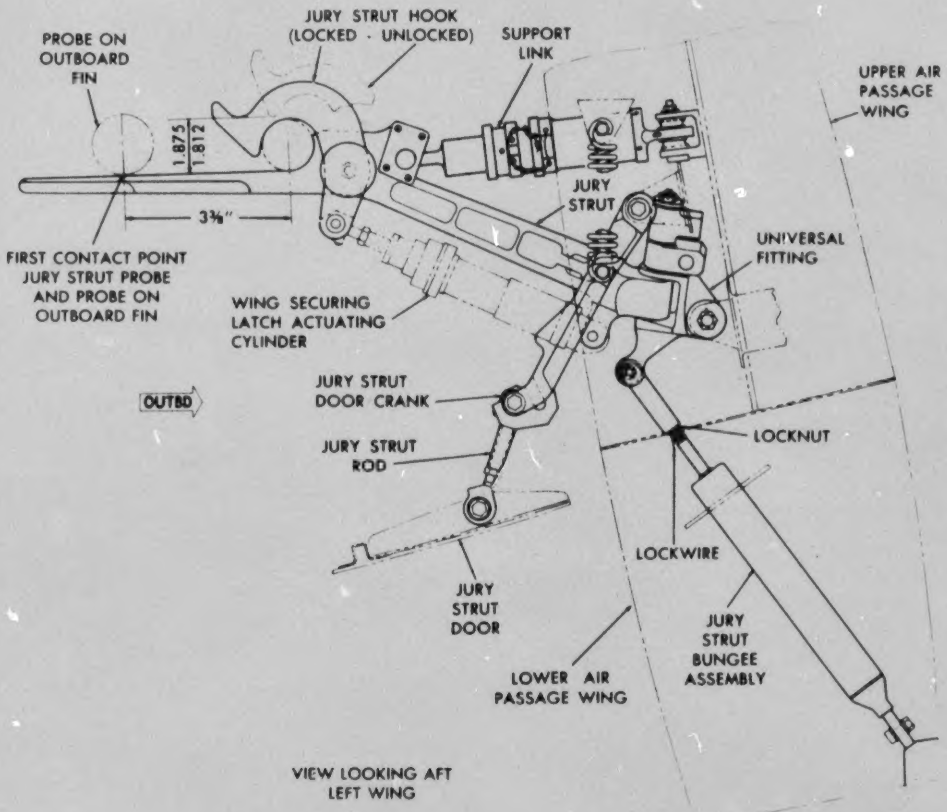
Figure 10-4.—Wing fold hydraulic schematic (C-2).

fold port of the wing fold cylinder, causing the wing to fold. Pressure is also directed to the extend port of the wing securing probe actuating cylinder.

When the wing securing probe actuating cylinder is fully extended, back pressure shifts the shuttle valve to route fluid through the jury strut priority valve to the retract port of the wing securing probe actuating cylinder. The pressure in the cylinder equalizes after the cylinder is extended. When the wing is completely folded, the jury strut latch engages the probe on the outboard fin as illustrated in figure 10-5, and the support link locks the wing in the folded position.

The fold joint gap closure doors are forced open during folding operations by the wing outer panel structure. Cables attached to the doors and to fold joint gap closure door bungees compress the springs in the bungees.

Setting the wing fold control lever to the SPREAD position actuates the wing fold control lever control switch to energize the spread solenoid of the selector valve. The wing fold selector valve opens a return line for the wing fold actuating cylinders and wing lock cylinders. The residual pressure valve maintains a pressure of 240 psi on the unlock port of the beam wing lock cylinders to prevent piston creepage. Pressure is directed through the aileron and wing fold swivel to the wing spread timer valve where


JURY STRUT HOOK
(LOCKED - UNLOCKED)
PROBE ON OUTBOARD FIN
SUPPORT LINK
UPPER AIR PASSAGE WING
1.875
1.812
3⅜"
JURY STRUT
FIRST CONTACT POINT JURY STRUT PROBE AND PROBE ON OUTBOARD FIN
UNIVERSAL FITTING
WING SECURING LATCH ACTUATING CYLINDER
OUTBD
JURY STRUT DOOR CRANK
LOCKNUT
JURY STRUT ROD
LOCKWIRE
JURY STRUT DOOR
JURY STRUT BUNGEE ASSEMBLY
LOWER AIR PASSAGE WING
VIEW LOOKING AFT LEFT WING

216.195

Figure 10-5.—Jury strut probe to fin locking mechanism.

it is maintained until the timer valve plunger is depressed. Pressure is also directed to the extend port of the wing securing latch actuating cylinder, disengaging the jury strut latch from the probe.

When the jury strut latch actuating cylinder is extended, back pressure shifts the shuttle valve and directs pressure through the priority valve to the retract port of the wing securing probe actuating cylinder, which retracts the jury strut mechanism and stows it in the wing outer panel. Pressure is also directed through the lock valve wing spread pressure release valve and flow regulator to the retract port of the wing fold cylinder, spreading the wings.

The wing spread timer valve is actuated by a striker bolt on the outer wing panel and allows pressure to pass through the valve and wing fold rib hydraulic pressure manifold to the lock ports of the beam wing lock cylinders. With these cylinders locked, the wing fold lock lever is moved to the locked position. The movement of the wing fold lock lever moves the wing lock-unlock lever to mechanically lock the beam lock cylinders and retract the warning flags. The fold joint closure doors are closed by the spring-loaded action of the closure bungees.

Components

Many of the C-2 wing fold system components are covered in *AMH 3 & 2* and discussed in the previous wing fold systems. Several of the components are discussed in the following paragraphs.

WING LOCK ACTUATING CYLINDER WITH TIMER VALVES.–Each wing lock cylinder is a two-port, double-acting type cylinder located on a beam lock fitting of the wing center section. Each cylinder has provisions for mounting a cam-actuated timer valve and a lock of the wing lock mechanism as illustrated in figure 10-6. The piston is a steel shaft with a large diameter on one end for a lockpin and a small diameter tail shaft. With the cylinder extended (locked) the wing lock-lock mechanism introduces a mechanical interference with the tail shaft to prevent hydraulic retraction of the locking piston until the lock-lock mechanism is unlocked.

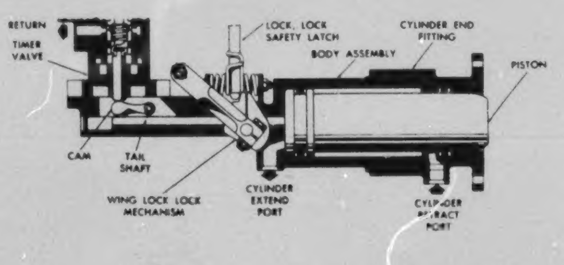


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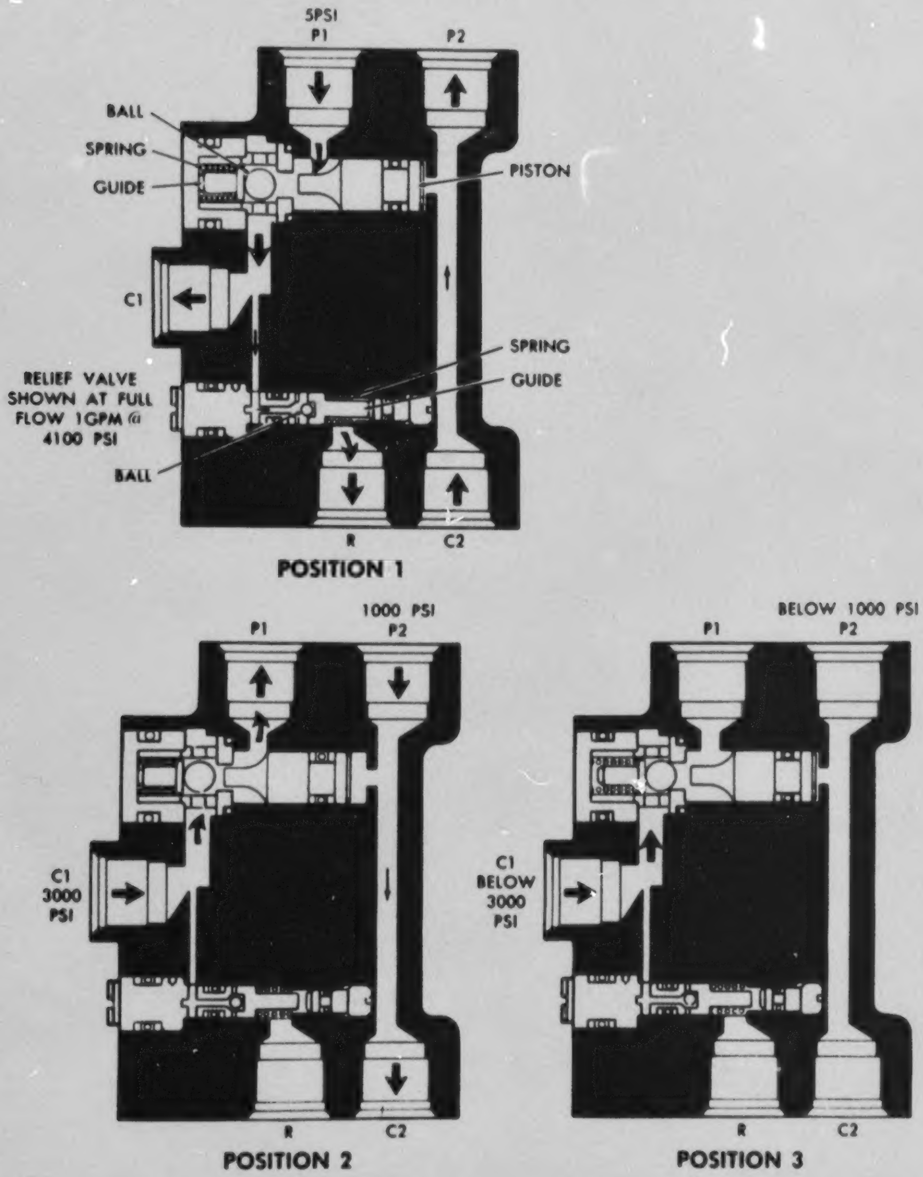
Figure 10-6.–Wing lock actuating cylinder.

When the mechanism is unlocked, the piston can retract to unlock the wing outer panel. The tail shaft actuates the timer valve. During wing folding operation, the valve plunger is depressed to prevent the flow of fluid to the jury strut system and the wing fold cylinder until each wing lock cylinder has completely retracted. During the spreading operation, the valve directs hydraulic fluid from the jury strut system and the wing fold cylinder to return.

LOCK VALVES.–A lock valve is located next to the wing fold cylinder in each wing outer panel. The valve restricts or dampens the folding motion of the wing if inadequate flow is maintained to keep up with wing breakaway. There are five port valves, each having a spread pressure inlet port (P1), spread pressure outlet port (C1), fold pressure inlet port (P2), fold pressure outlet port (C2), and a return port. Figure 10-7 illustrates the lock valve in the various positions described in the following paragraphs.

During the wing spread operation (position 1), fluid flow in the spread line is from P1 to C1 ports with return flow from C2 to P2 ports. If hydraulic pressure between ports P1 and C1 exceeds 4,100 psi, the relief valve will unseat and route fluid to return, relieving pressure in the spread line. The relief valve reseats at 3,360 psi minimum.

During the wing fold operation (position 2), fluid flow in the fold line is from P2 to C2 ports at a pressure of 1,000 psi. Return flow is from C1 to P1 ports at 3,000 psi. This condition


5PSI
P1
P2
BALL
SPRING
GUIDE
PISTON
C1
SPRING
GUIDE
RELIEF VALVE SHOWN AT FULL FLOW 1GPM @ 4100 PSI
BALL
R
C2
POSITION 1
1000 PSI
P1
P2
C1 3000 PSI
R
C2
POSITION 2
BELOW 1000 PSI
P1
P2
C1 BELOW 3000 PSI
R
C2
POSITION 3

216.197

Figure 10-7.—C-2 wing lock valve.

causes the valve piston to move against the ball, compressing the spring, since 1,000 psi at the larger area end of the piston will have a greater total force than 3,000 psi on the small area end of the piston. Fluid pressure drops past the ballpiston orifice and has no significant effect on the piston.

If the wing motion is in excess of that caused by fluid pressure between P2 and C2 ports (position 3), hydraulic pressure on the piston will drop below 1,000 psi; then, the check valve in the lock valve seats and restricts the flow of hydraulic fluid from the C1 to P1 ports. This traps fluid in the C1 port and stops wing movement until pressure is increased above 1,000 psi to unseat the check valve and permit flow from the C1 to the P1 port. If pressure in the C1 port builds up over 4,100 psi with the check valve seated, the relief valve opens to prevent further buildup of pressure.

WING SPREAD PRESSURE RELIEF VALVE.–This valve is a three-port, solenoid-operated hydraulic valve used to relieve pressure trapped in the wing fold actuating cylinder spread line. The valve is energized during fold and spread operations. It is deenergized when the wing fold lock lever is in the locked position. During wing fold operations, the valve directs fluid from the wing fold actuating cylinder spread port through the lock valve to return. During spreading operations, it directs pressure from the lock valve to the spread port of the wing fold cylinder. When deenergized, it directs fluid from the wing fold cylinder spread port to return.

WING FOLD/TAIL FOLD SYSTEMS

Larger naval aircraft such as the A-3 and A-5 feature a combination wing fold and tail fold system. The wing fold can be operated independent of the tail fold. The tail folding feature is generally used whenever hangar deck overhead clearances are minimal to prevent the possibility of vertical stabilizer tip damage. The wing fold/tail fold system of the A-5 is described in this section. Reference to figures 10-8 and 10-9 will aid in understanding system operation.

Description/Operation

The wing fold and tail fold system consists of the wing and tail fold handle assembly, two solenoid-operated selector valves, a lock valve, three sequence valves, six lockpin actuators, three priority valves, two wingfold actuating cylinders, and a vertical stabilizer fold actuating cylinder.

The wing and tail fold handle operates the mechanical lock system and the wing and tail fold selector switch. The tail control switch, located adjacent to the wing and tail fold handle, can be manually actuated to permit folding of the wings only. The hydraulic subsystem isolation switch isolates the wing and tail fold system from the essential flight control systems during flight.

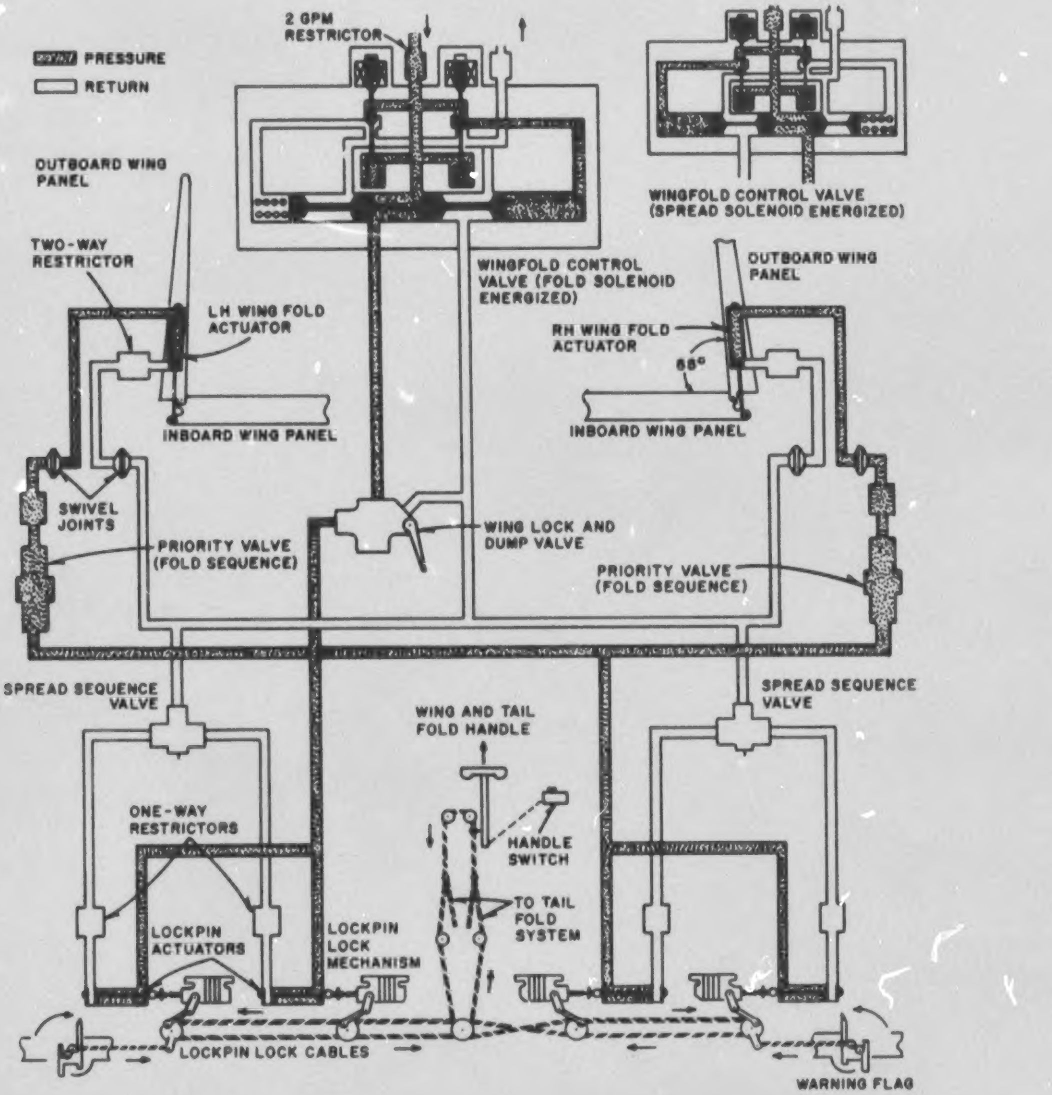
Control of the wing and tail folding and unfolding is accomplished through two four-port, solenoid-operated control valves, which are controlled by the selector switch and the tail control switch if selected. The tail fold control valve and the wing fold lock valve incorporate a manual dump provision which permits manual folding of the tail and wing panels when hydraulic power is not available.

The system is powered by pressure from the No. 2 hydraulic power system. The lockpin cylinders and the wing and tail fold actuating cylinders are hydraulically and mechanically sequenced and electrically controlled. Restrictors are installed in the fold and spread lines to control the rate of operation.

Fold and spread operations are possible only when the landing gear handle is in the down position, leading edge droops are in the fully up position, and the aircraft weight is on the landing gear. The wings must not be manually spread unless the droops are fully up.

Pulling on the wing and tail fold control handle causes the attached cable assemblies to unlock the lockpin mechanical locks and extend the warning flags. The handle must be rotated to the UNLOCK position before it can be pulled. Rotating the wing and tail fold control handle to the LOCK position completes the electrical circuit to the fold solenoid of the selector valves.

With the tail control switch OFF, the circuit is completed to the wing fold control valve

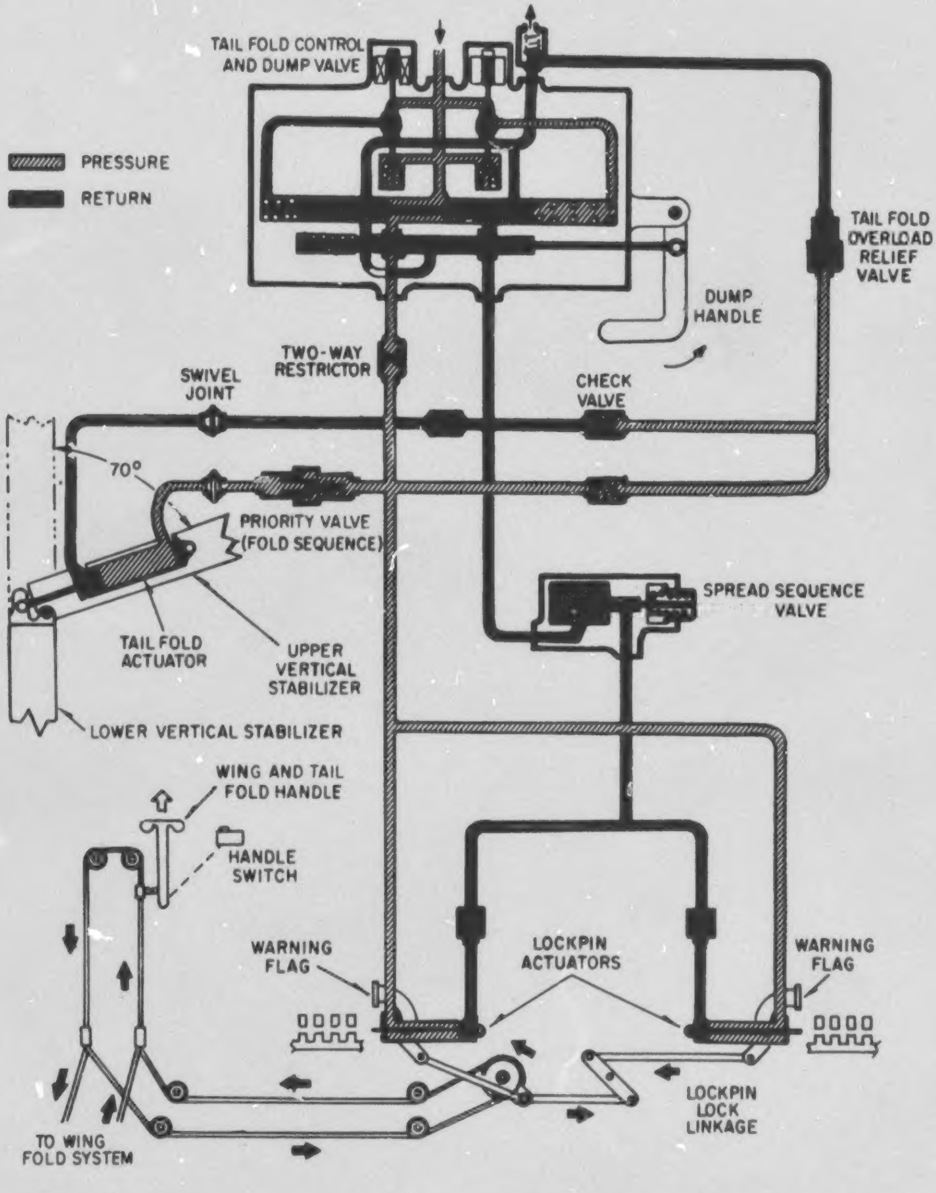

▨ PRESSURE
☐ RETURN
2 GPM RESTRICTOR
OUTBOARD WING PANEL
WINGFOLD CONTROL VALVE (SPREAD SOLENOID ENERGIZED)
TWO-WAY RESTRICTOR
LH WING FOLD ACTUATOR
WINGFOLD CONTROL VALVE (FOLD SOLENOID ENERGIZED)
OUTBOARD WING PANEL
RH WING FOLD ACTUATOR
68°
INBOARD WING PANEL
INBOARD WING PANEL
SWIVEL JOINTS
PRIORITY VALVE (FOLD SEQUENCE)
WING LOCK AND DUMP VALVE
PRIORITY VALVE (FOLD SEQUENCE)
SPREAD SEQUENCE VALVE
SPREAD SEQUENCE VALVE
WING AND TAIL FOLD HANDLE
ONE-WAY RESTRICTORS
HANDLE SWITCH
TO TAIL FOLD SYSTEM
LOCKPIN ACTUATORS
LOCKPIN LOCK MECHANISM
LOCKPIN LOCK CABLES
WARNING FLAG

216.198

Figure 10-8.—Wing fold (A-5) schematic.

solenoid only. Hydraulic pressure is ported by the control valves through the wing and tail fold lines to the lockpin actuating cylinders to pull the lockpins. When the lockpins have fully retracted, pressure buildup unseats the priority valves in the fold lines and fluid enters the fold side of the actuating cylinders.

Unfolding is accomplished by rotating the wing and tail fold control handle to "UNLOCK," thus repositioning the selector switch to energize the spread solenoids of the control valves. The handle must be lifted slightly before rotation to the "UNLOCK" position is possible. Pressure is directed to the spread port

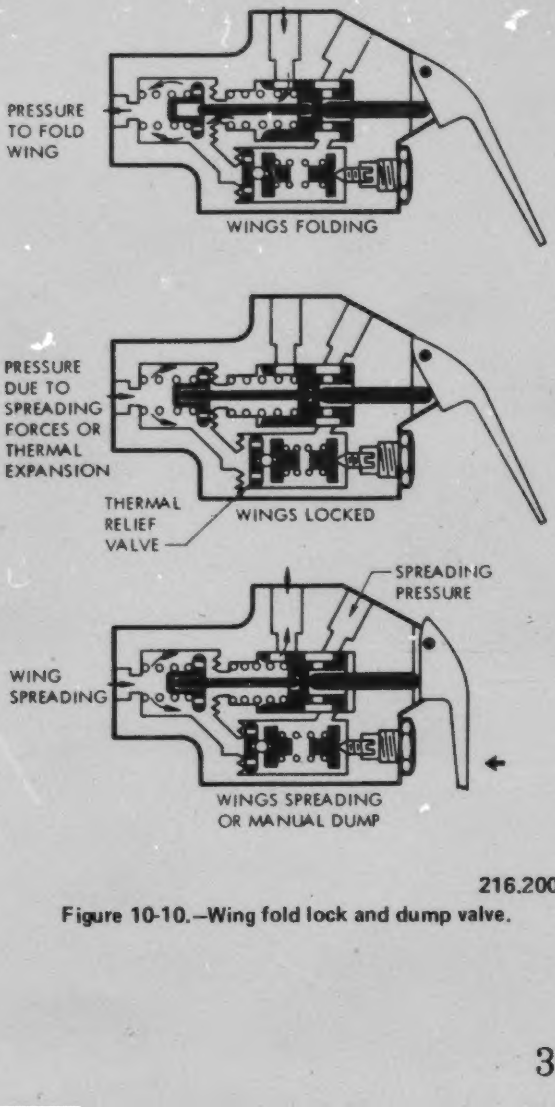

TAIL FOLD CONTROL AND DUMP VALVE
▨ PRESSURE
■ RETURN
TAIL FOLD OVERLOAD RELIEF VALVE
DUMP HANDLE
TWO-WAY RESTRICTOR
SWIVEL JOINT
CHECK VALVE
70°
PRIORITY VALVE (FOLD SEQUENCE)
SPREAD SEQUENCE VALVE
TAIL FOLD ACTUATOR
UPPER VERTICAL STABILIZER
LOWER VERTICAL STABILIZER
WING AND TAIL FOLD HANDLE
HANDLE SWITCH
WARNING FLAG
LOCKPIN ACTUATORS
WARNING FLAG
LOCKPIN LOCK LINKAGE
TO WING FOLD SYSTEM

216.199

Figure 10-9.–Tail fold (A-5) schematic.

of each panel actuator and to the lockpin sequence valves. Pressure is blocked at the sequence valves until the valves are actuated by the panels as they reach the spread position. The sequence valves then direct pressure to the extend (lock) port of each lock cylinder.

The actuating speed of the various actuators is controlled by restrictor valves. Wing fold return flow during the spread cycle must flow through the wing fold lock valve. The lock valve is unlocked internally by pressure from the spread line. The hydraulic lock in the tail fold actuator is released, and fluid is ported to return by the spread solenoid in the control valve. When spreading is complete, the lockpins are secured, the warning flags are retracted, and the switch is locked in the spread position by moving the wing and tail fold control handle down and rotating it to the "LOCK" position.



216.200

Figure 10-10.—Wing fold lock and dump valve.

WING FOLD LOCK AND DUMP VALVE.—The lock and dump valve (fig. 10-10) traps hydraulic fluid in the fold line and locks the wings in the fold position when jury struts are not installed. If the wings have been folded manually, the lock valve will not be effective.

The lock valve consists of a controllable check valve, a manual spreading lever and a thermal relief valve. The controllable check valve allows free flow in the folding sequence. The check valve must be unseated for the wings to spread. Spreading may be accomplished manually by depressing the spread lever on the valve or hydraulically by means of a special piston and plunger incorporated in the valve's internal mechanism. When the wing fold control valve ports pressure to spread the wings, pressure is applied to the lock valve piston. Movement of the piston unseats the check valve, allowing return flow in the lines.

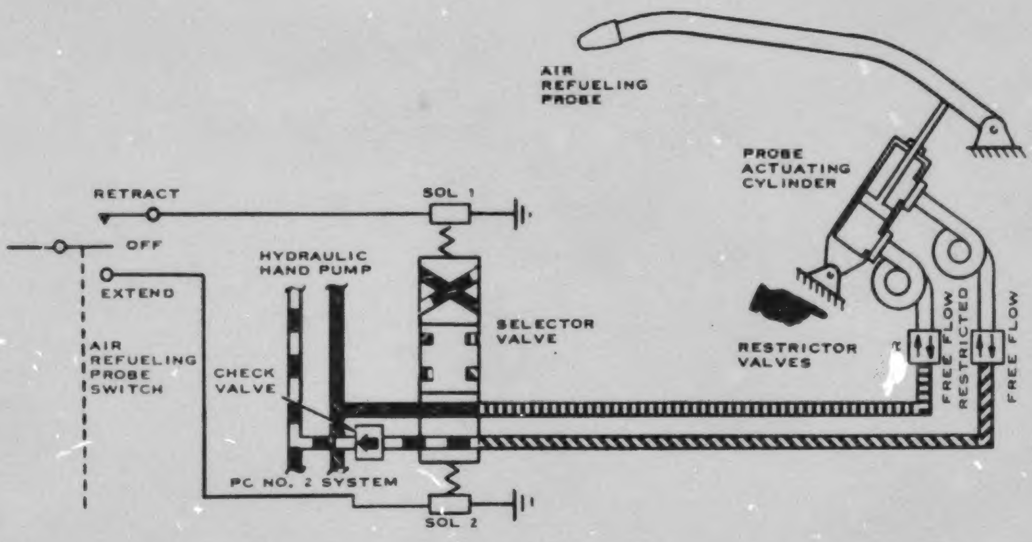
TAIL FOLD CONTROL AND DUMP VALVE.—The pressure dumping feature for manual operation of the tail panel is incorporated into the tail fold control (selector) valve (fig. 10-9). When both solenoids are in the deenergized position, the valve returns to the neutral position and remains there. Manual operation of the valve is accomplished by depressing the lever, which is an integral part of the valve.

AIR REFUELING PROBE EXTENSION AND RETRACTION SYSTEM

Air refueling systems permit complete in flight or on the ground refueling of the aircraft fuel system and in most aircraft include external stores and inflight refueling tanker packages.

DESCRIPTION/OPERATION (A-7)

The refueling probe extension and retraction system of the A-7 is illustrated in figure 10-11. It consists of the refueling probe; refueling nozzle; a self-locking, two-position probe



216.201

Figure 10-11.–Air refueling probe (A-7) hydraulic system.

actuating cylinder; lock swivel joint; two restrictor valves; a selector valve; and associated electrical switches, relays, etc.

With the engines operating or external electrical and hydraulic power applied, the probe is extended by placing the refueling probe switch in the EXTEND position. This electrically actuates the solenoid selector valve to supply restricted hydraulic pressure to the extend port of the probe actuating cylinder. The restrictor valves control the rate of cylinder extension and retraction. The check valve prevents pressure surges in the hydraulic return system from unlocking the probe actuating cylinder during flight.

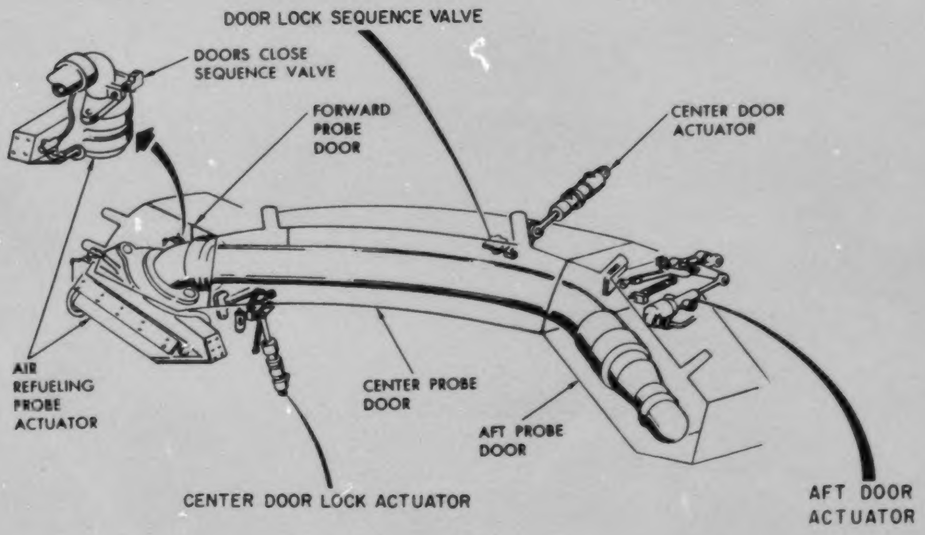
After disengaging the probe nozzle from the tanker drogue, holding the air refueling switch in RETRACT actuates the solenoid selector valve to supply pressure to the retract port of the probe actuating cylinder, causing it to retract and lock the probe into place. A cockpit advisory panel transit light goes out whenever the probe is locked in the extended or retracted position. A probe floodlight, which illuminates the probe tip for visual contact with the refueling drogue at night, is on whenever the refueling probe switch is in EXTEND and exterior lights are on. The flood light goes out when the refueling probe switch is placed in RETRACT or OFF.

DESCRIPTION/OPERATION (A-5)

The refueling probe system of the A-5 represents a more complex system than the A-7. The probe is completely enclosed within the fuselage and covered by three fairing doors when in the retracted position. The A-5 probe installation is illustrated in figure 10-12.

The forward door is spring-loaded to the closed position and follows the movement of the probe as it extends and retracts. The center and aft doors are hydraulically operated. The forward door is held closed by the overlapping center door, which is locked closed by a hydraulically operated hook type lock arrangement. The aft door is locked in the closed position by the mechanical overcenter lock mechanism attached to the aft door actuator linkage.

Figure 10-13 illustrates the air refueling probe control system of the A-5 in the probe



216.202

Figure 10-12.—Air refueling probe installation (A-5).

extending condition. With solenoid-operated control valve in the EXTEND position, fluid is ported under pressure through the extend lines to the center fairing door lock cylinder and to the aft door actuating cylinder. As the center door unlocks, a plunger on the lock sequence valve is depressed and fluid is ported to the center door actuator. After the center and aft doors are fully open, a pressure buildup in the extend line opens the priority valve and extends the refueling probe. When the probe reaches the fully extended position, an internal sequence valve in the actuator ports pressure to a hydraulically actuated lockpin to lock the probe in the extended position.

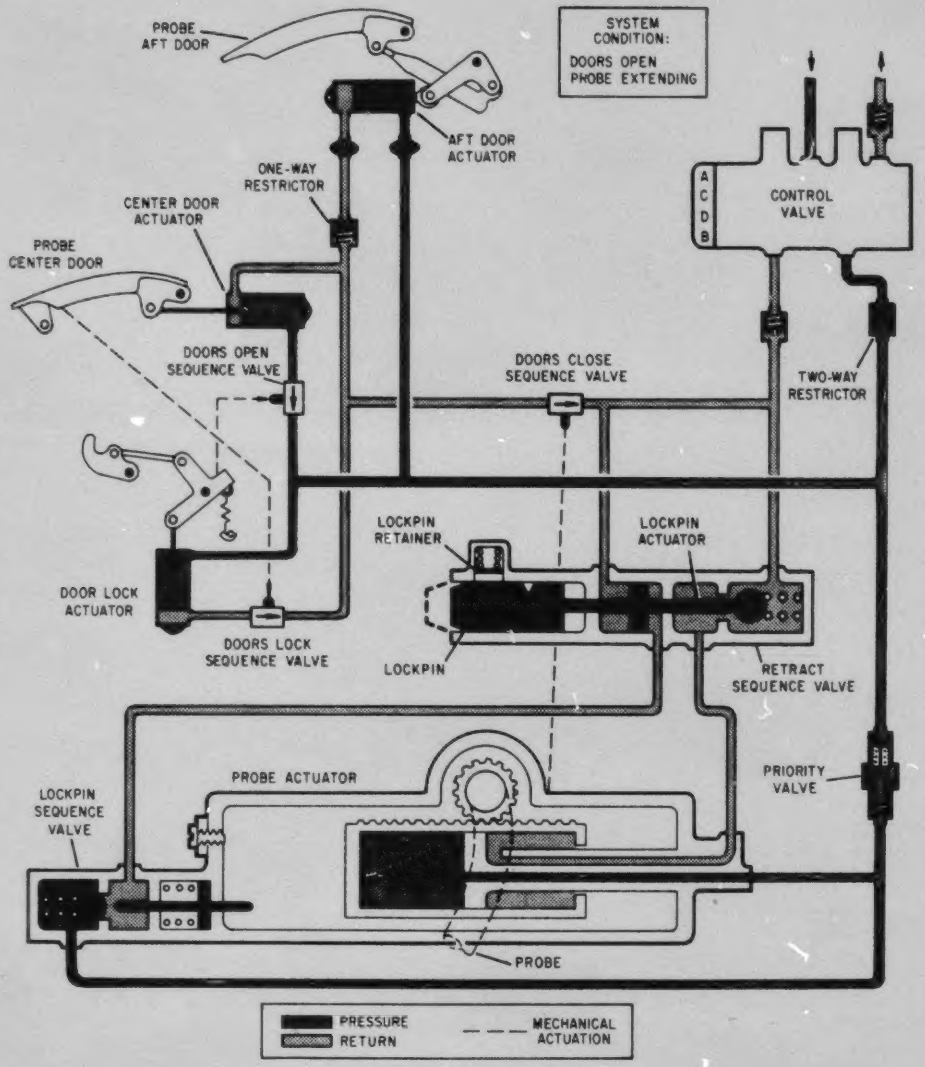
Positioning the fuel probe selector switch to RETRACT ports fluid from the probe control valve through the retract lines to unlock the probe lockpin and retract the probe. The spring-loaded forward door follows the movement of the probe to the fully closed position. When the probe is fully retracted, a plunger on the doors close sequence valve is depressed and fluid is ported to the center and aft door actuating cylinders. The aft door is closed and locked by the actuating cylinder and an overcenter lock mechanism. As the center door closes, a plunger on the lock sequence valve is depressed and the fluid is ported to the center door lock actuating cylinder. The cylinder locks the center fairing door in place, completing the retract cycle.

MAINTENANCE

Organizational maintenance of the air refueling probe system normally consists of operational checks, troubleshooting, rigging and adjusting, and removal and installation of components.

To perform an operational check of the air refueling probe system of the A-5, the hydraulic system must be pressurized to 3,000 psi, external electrical power applied, and the inflight refueling circuit breaker engaged. Prior to actuating the system, ensure that all personnel and equipment are clear of the area of probe travel. The extension cycle rotates the probe from its aft stored position through approximately 150° to a forward locked position.

Position the fuel probe switch to EXTEND. Check that the aft and center doors unlock and open. Check for proper probe extension,


PROBE AFT DOOR
SYSTEM CONDITION:
DOORS OPEN
PROBE EXTENDING
AFT DOOR ACTUATOR
ONE-WAY RESTRICTOR
CENTER DOOR ACTUATOR
PROBE CENTER DOOR
A
C
D
B
CONTROL VALVE
DOORS OPEN SEQUENCE VALVE
DOORS CLOSE SEQUENCE VALVE
TWO-WAY RESTRICTOR
LOCKPIN RETAINER
LOCKPIN ACTUATOR
DOOR LOCK ACTUATOR
DOORS LOCK SEQUENCE VALVE
LOCKPIN
RETRACT SEQUENCE VALVE
PROBE ACTUATOR
PRIORITY VALVE
LOCKPIN SEQUENCE VALVE
PROBE
PRESSURE
RETURN
MECHANICAL ACTUATION

216.203

Figure 10-13.—Air refueling probe system schematic (A-5).

followup of the forward door, and probe locking. If operation of the probe is not smooth, check for air in the system. Position the fuel probe switch to RETRACT and check for proper probe retraction, positive followup action of the forward door, aft door closing followed by center door closing, and iocking of doors.

The complete extension cycle should be from 5 to 7 seconds with the retraction cycle taking from 9 to 11 seconds.

Troubleshooting of the system should include a thorough knowledge of the malfunction compared to proper system operation, and referral to system schematics and troubleshooting tables provided in the

Maintenance Instructions Manual. System rigging, component removal and installation, and all other maintenance should be in accordance with the procedures and safety precautions outlined in the Maintenance Instructions Manual. Quality assurance considerations are required at each step appearing in italics or otherwise designated.

Intermediate maintenance of faulty components consists of curedate kit installation and testing in accordance with the intermediate maintenance section of the Maintenance Instructions Manual or the applicable (03) Overhaul Manual.

WINDSHIELD WIPER SYSTEM

A hydraulically operated windshield wiper system is provided in the P-3A aircraft. Power for operation of the system is taken from the No. 1 hydraulic system line which supplies pressure to the bomb bay door actuating system. The wiper system consists of a pressure reducer, speed control needle valve and drive mechanism, hydraulic actuator, two window actuator units and wiper blade assemblies, and a return line check valve.

OPERATION

The windshield wiper system is illustrated in figure 10-14. System pressure is directed to the pressure reducer where it is reduced to 2,000 psi, and then the fluid passes to the speed control valve, which starts, stops, and controls the wiper blade speed.

Hydraulic fluid is directed from the speed control unit to the hydraulic actuator which, in turn, controls and directs fluid to the window units. The actuator alternately allows fluid flow to opposite sides of the window unit double piston. To provide a constant speed of the wiper blade, fluid from the speed control valve is directed to balance pistons in the hydraulic actuator as well as directly to the window units through the hydraulic actuator normal inlet port. The window units, by action of a rack and piston arrangement, convert the linear motion of the double piston to the reciprocating action of the drive shaft.

A parking brake assembly (part of the window unit) mechanically locks and hydraulically unlocks the window units, thereby providing a parked and locked position for the blades. The arc and speed of the blades will vary with position of the control knob of the speed control unit to a maximum of 300 strokes per minute and an arc of from 75 degrees (high speed) to 91 degrees (low speed) on parking. The wiper arm moves an additional 10 degrees (to the parked or stowed position) off the glass. A minimum pressure of 800 psi is required to operate the wipers to their full stroke and stop.

When the system has completed one wiper stroke and the hydraulic pressure at the window unit pistons reaches a value equal to system pressure minus 200 psi, the actuator will then reverse the flow to the opposite side of the window unit piston and repeat the wiper stroke action in reverse.

Any obstruction on one windshield will stop that blade, but allow the other to continue until it completes its stroke (or meets an obstruction), at which time the pressure in the window units build up and the actuator reverses the action of both blades. The mechanical locking device is provided to hold the blades in the parked position when the needle valve is closed.

NOTE: Do not operate the windshield wiper blades on a dry windshield.

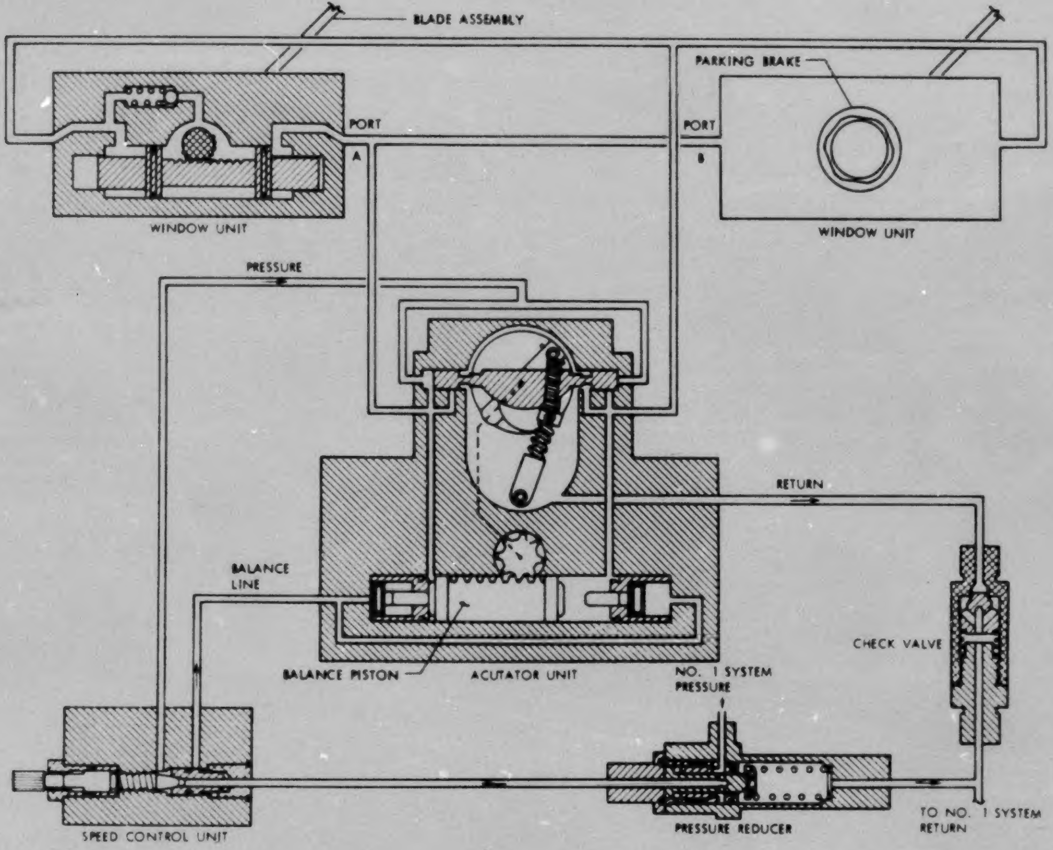
MAINTENANCE

Maintenance of the windshield wiper system consists mainly of operational checks, removal and installation of components, and troubleshooting.

Operational Check

The operational check should be performed according to the following procedure:

1. Provide a supply of water on the outside surface of the panels when the wiper blades are in motion.
2. Check for wiper arm force on the windshield at the blade attachment of 7 to 10 pounds.
3. Connect external electrical power supply.


BLADE ASSEMBLY
PARKING BRAKE
PORT
A
PORT
B
WINDOW UNIT
WINDOW UNIT
PRESSURE
RETURN
BALANCE LINE
CHECK VALVE
BALANCE PISTON
ACUTATOR UNIT
NO. 1 SYSTEM PRESSURE
SPEED CONTROL UNIT
PRESSURE REDUCER
TO NO. 1 SYSTEM RETURN

216.204

Figure 10-14.—Windshield wiper schematic.

4. Energize hydraulic-power system No. 1 ac pumps.

CAUTION: Do not start hydraulic pumps together. Wait 5 seconds minimum between actuation of each pump switch to ON.

5. Slowly open the windshield wiper speed control needle valve.

6. Blades must move from parked position and begin to cycle between 100 to 300 strokes per minute.

7. Open instrument panel to gain access to window units. Bleed air from units as they cycle by cracking the B-nuts on the tubing at each end of the window units. Allow fluid to bleed into existing drip pans until it is evident that all air has been dissipated.

8. Check that no hydraulic fluid leak is visible in the system tubing, connections, or at any component.

9. Check that system components perform smoothly with no erratic operation and blade reversing is synchronized. Blade rotation must be 75 degrees. The wiper blades must not touch the center post, travel into the parking area, or short cycle during high speed operation.

10. Reduce speed of blade operation, and manually stall each wiper separately. While the blade is stalled, the opposite blade should operate smoothly.

11. Park the blades by slowing down the cycling speed to permit blades to move into the park position before they reverse.

NOTE: Parking area is the area between the bottom edge of the glass and the break in the contour of the fuselage. To adjust the blades, loosen the blade attaching screw and rotate blade. One serration is approximately 5 degrees of rotation. If it is not possible to install within the parking area, install the arm outboard with the blades as close to the parking area as possible, then remove the arm and adapter. Looking down on the arm, carefully remove the adapter and rotate it one serration counterclockwise with respect to the arm, then reinstall the adapter in the arm. This will permit the arm to be installed approximately 1.25 inches closer to the parking area. If the blade is still parked on the glass, repeat above procedure. Final adjustment must leave slots in the adapter and arm approximately in line to permit proper clamping action of the arm and adapter to the shaft of the window unit. Figure 10-15 illustrates a windshield wiper unit.

12. When the blades are in the park position, quickly close the needle valve.

13. Deenergize hydraulic power system No. 1 ac pumps, and remove external electrical power.

GENERATOR DRIVE SYSTEM (HYDRAULICALLY OPERATED)

The ac generator drive system of the T-39 is hydraulically operated by pressure from the hydraulic power system. The system is controlled by a shutoff valve which is operated by the AC GEN switch on the copilot's subinstrument panel. The system is illustrated in figure 10-16 and consists of a shutoff valve, a hydraulically driven motor, a heat exchanger, a control switch, and relay.

OPERATION

During normal aircraft operation, and with the AC GEN switch at OFF, the solenoid operated shutoff valve is energized (closed). The hydraulic motor lockout relay is also energized. Under this condition, the generator does not operate, since hydraulic pressure is stopped at the shutoff valve. When the AC GEN switch is moved to ON, the hydraulic motor lockout relay and the shutoff valve are deenergized and the valve opens. Hydraulic fluid at 3,000 psi is directed to operate the constant speed variable displacement motor at 8,000 rpm. When the fluid exits from the motor into the return lines, it is routed through a heat exchanger and ram air cooled before returning to the power system reservoir. On the deck when ram air is not available, an electrically driven blower is engaged automatically to provide airflow.

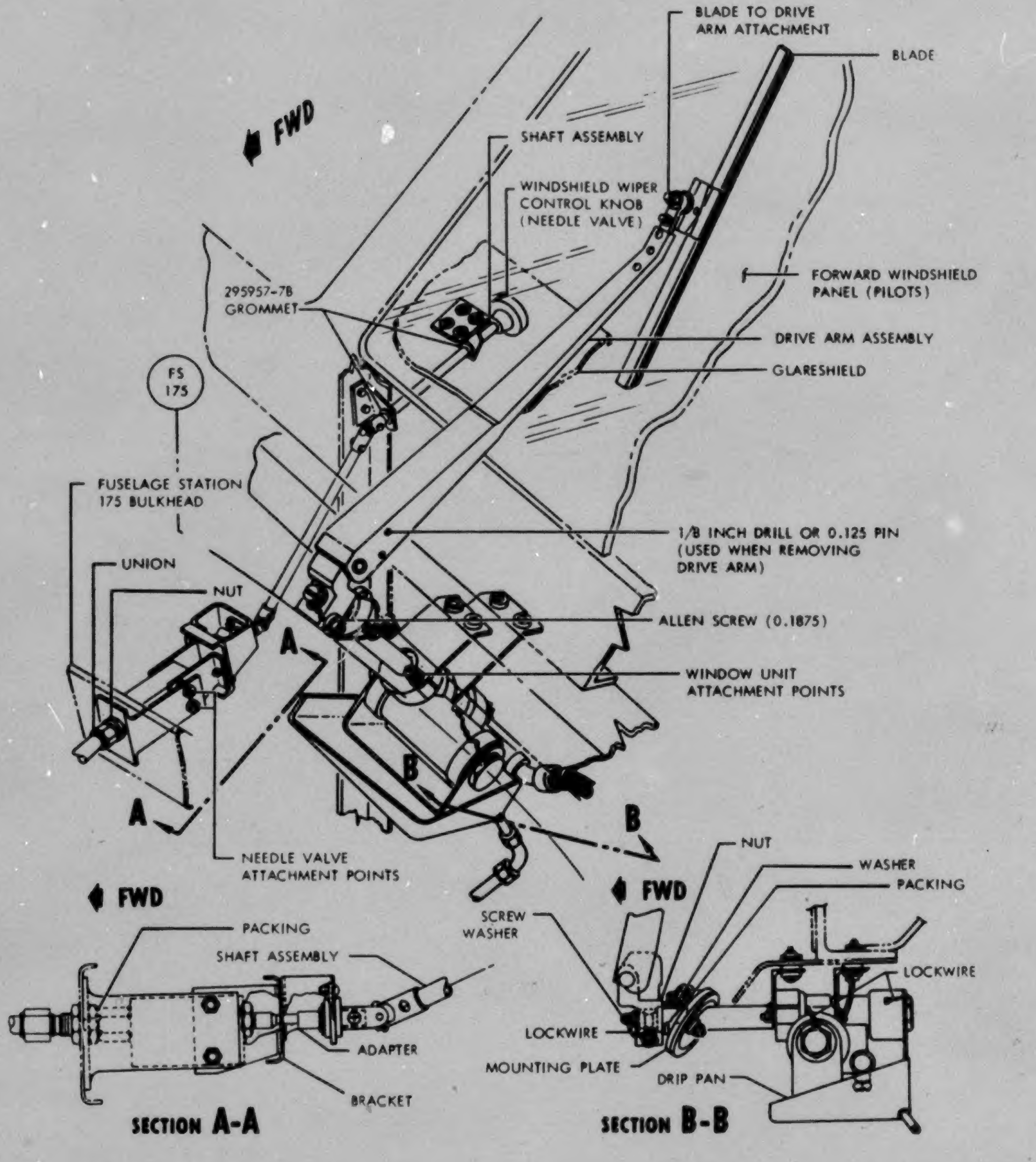
SHUTOFF VALVE

The generator drive system shutoff valve is a three-way, pilot-operated, solenoid-controlled, normally open valve. When deenergized, pressurized hydraulic fluid is ported directly to the drive system motor. In the energized position (valve shut off), fluid flow is ported from the drive motor return line back to the drive motor inlet, preventing cavitation of the motor and allowing fluid to flow through the motor and the shutoff valve in a continuous loop whenever the system is first shut down and the motor is coasting to a stop. The normally open shutoff valve is spring-loaded to the open position, making it a fail safe unit.

DRIVE MOTOR

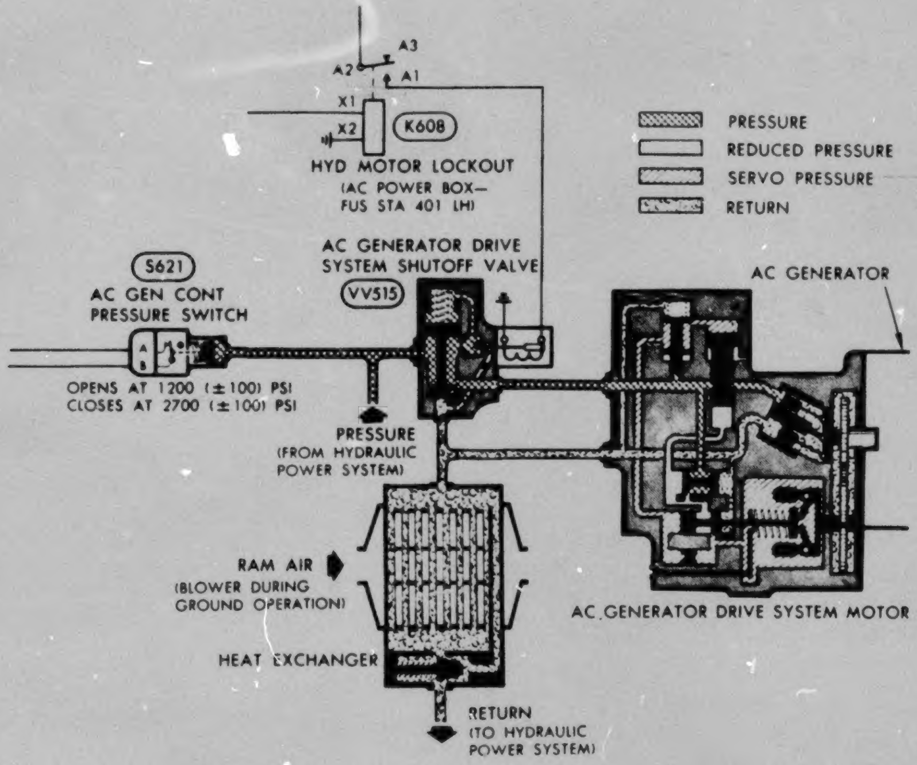
The generator drive motor is designed to operate in a 3,000-psi, 7.8-gpm minimum, constant pressure, variable delivery system. The motor shaft rotates at a constant speed of 8,000 rpm (±400) at any load within a specified range. The motor consists of a modified Vickers rotating group, a start valve, and a governor with associated buffer and pressure regulator. The rotating group is a Vickers axial piston fixed angle type, which consists of a cylinder block, pistons, piston rods, universal link, shaft, and bearings. The standard rotating group is modified by the addition of a gear on the shaft to drive the governor.

The start valve, shown in figure 10-16, is a three-way valve, operated by the inlet pressure. When the motor inlet pressure is normal, the


BLADE TO DRIVE ARM ATTACHMENT
BLADE
FWD
SHAFT ASSEMBLY
WINDSHIELD WIPER CONTROL KNOB (NEEDLE VALVE)
FORWARD WINDSHIELD PANEL (PILOTS)
295957-7B GROMMET
DRIVE ARM ASSEMBLY
GLARESHIELD
FS 175
FUSELAGE STATION 175 BULKHEAD
1/8 INCH DRILL OR 0.125 PIN (USED WHEN REMOVING DRIVE ARM)
UNION
NUT
ALLEN SCREW (0.1875)
A
WINDOW UNIT ATTACHMENT POINTS
B
A
B
NEEDLE VALVE ATTACHMENT POINTS
FWD
NUT
WASHER
PACKING
FWD
PACKING
SCREW WASHER
SHAFT ASSEMBLY
LOCKWIRE
LOCKWIRE
ADAPTER
MOUNTING PLATE
DRIP PAN
BRACKET
SECTION A-A
SECTION B-B

216.205

Figure 10-15.–Windshield wiper unit.


A3
A2
A1
X1
X2
K608
HYD MOTOR LOCKOUT
(AC POWER BOX—
FUS STA 401 LH)
PRESSURE
REDUCED PRESSURE
SERVO PRESSURE
RETURN
S621
AC GEN CONT
PRESSURE SWITCH
AC GENERATOR DRIVE
SYSTEM SHUTOFF VALVE
VV515
AC GENERATOR
A
B
OPENS AT 1200 (± 100) PSI
CLOSES AT 2700 (± 100) PSI
PRESSURE
(FROM HYDRAULIC
POWER SYSTEM)
RAM AIR
(BLOWER DURING
GROUND OPERATION)
AC GENERATOR DRIVE SYSTEM MOTOR
HEAT EXCHANGER
RETURN
(TO HYDRAULIC
POWER SYSTEM)

216.206

Figure 10-16.—AC generator drive system (T-39).

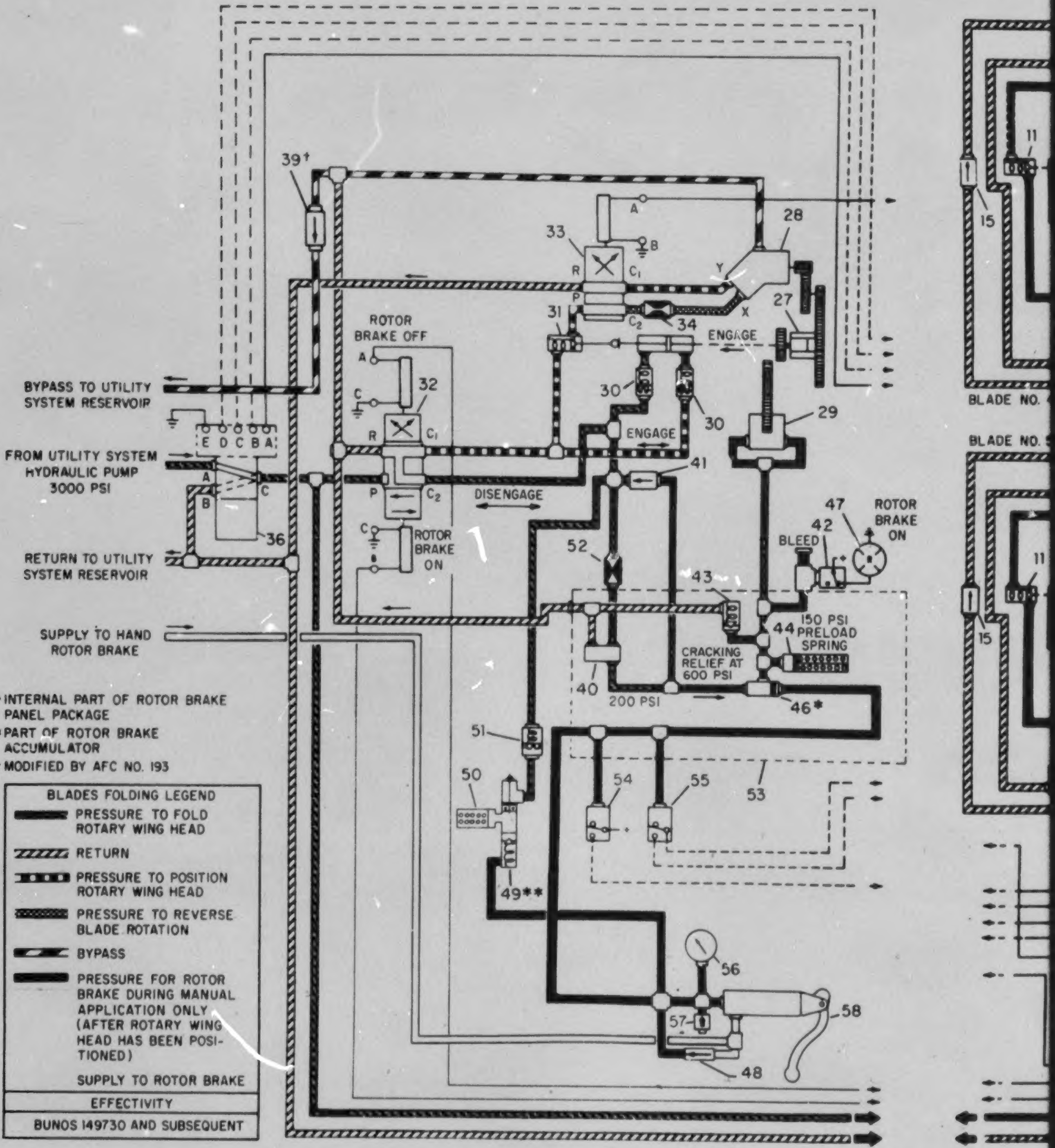
valve exposes the larger rack-actuated piston to control pressure from the governor. The valve connects the piston to a return passage when the motor inlet pressure is less than about 1,800 psi. Low inlet pressure occurs during the starting of the motor when displacement is maximum and there is sufficient flow to drive the motor at governed speed. During acceleration, the start valve causes the displacement to decrease and the motor shaft speed to increase.

The centrifugal governor is a standard design with flyweights controlling the position of a servo valve spool. A pressure reducer supplies hydraulic pressure at 750 psi from the motor inlet passage to the governor servo valve and to the smaller rack-actuating piston. A buffer is located in the passage between the governor servo valve and the larger actuating piston and consists of a cylinder, containing a piston, centered between two springs. There is a metering orifice through the piston.

When a sudden speed change occurs, the governor automatically varies the control fluid flow, and the buffer piston immediately becomes displaced. At the same time, the rack-actuated piston is moved to change the motor displacement. While the buffer piston is off center, a pressure differential exists between the two ends. Each end of the buffer cylinder communicates with one end of the servo valve spool.

Whenever flow is transmitted to either direction by the buffer piston, a feedback signal is produced in the form of differential pressure on the servo valve spool. The net force due to this pressure is always in the direction to return the valve spool to the null position. This arrangement minimizes overspeed and the

1. Manifold.
2. Damper-positioner snubber valve.
3. Damper-positioner shuttle valve.
4. Blade fold accumulator.
5. Blade fold accumulator air valve.
6. Blade fold accumulator gage.
7. Flow control valve.
8. Flow control valve.
9. Blade lock cylinder (top of sleeve-spindle).
10. Blade folded limit switch.
11. Blade lockpin sequence valve (internal part of blade lock cylinder).
12. Blade lockpin limit switch (top of sleeve-spindle).
13. Blade locked sequence valve.
14. Blade spread sequence valve.
15. Check valve.
16. Control lockpin limit switch (internal part of control lock cylinder).
17. Control lock cylinder.
18. Pressure snubber.
19. Check valve.
20. Control lock cylinder sequence valve.
21. Damper-positioner sequence valve (internal part of damper-positioner).
22. Damper-positioner.
23. Blade lockpin sequence valve (internal part of blade lock cylinder).
24. Blade lock cylinder (bottom of sleeve-spindle).
25. Blade lockpin limit switch (bottom of sleeve-spindle).
26. Blade fold cylinder.
27. Blade positioner drive unit.
28. Blade positioner hydraulic motor.
29. Rotor brake.
30. Restrictor filter (1-way).
31. Sequence valve (internal part of positioner drive unit).
32. Blade positioner control valve.
33. Blade rotation control valve.
34. Restrictor filter (2-way).
35. Blade fold control valve.
36. Safety valve (motor operated).
37. Rotor coupling.
38. Lock valve.
39. Check valve.
40. Pressure reducer.
41. Check valve.
42. Rotor brake pressure switch (10 psi).
43. Relief valve.
44. Panel package accumulator.
45. Lock valve limit switch.
46. Shuttle valve.
47. Rotor brake on light.
48. Check valve.
49. Sequence valve.
50. Rotor brake accumulator.
51. Pressure snubber.
52. Restrictor filter (two-way).
53. Rotor brake panel package.
54. Rotor brake pressure switch (10 psi).
55. Rotor brake pressure switch (300 psi).
56. Rotor brake pressure gage.
57. Check valve.
58. Rotor brake master cylinder.


39†
33
A
B
R
C1
P
C2
28
Y
X
27
31
34
ENGAGE
ROTOR BRAKE OFF
A
C
32
R
C1
P
C2
DISENGAGE
C
ROTOR BRAKE ON
30
30
ENGAGE
29
41
BYPASS TO UTILITY SYSTEM RESERVOIR
E D C B A
FROM UTILITY SYSTEM HYDRAULIC PUMP 3000 PSI
A
B
C
36
RETURN TO UTILITY SYSTEM RESERVOIR
SUPPLY TO HAND ROTOR BRAKE
52
43
47
ROTOR BRAKE ON
42
BLEED
44
150 PSI PRELOAD SPRING
CRACKING RELIEF AT 600 PSI
40
200 PSI
46*
51
53
50
54
55
49**
56
57
58
48
11
15
BLADE NO. 4
BLADE NO. 5
11
15

* INTERNAL PART OF ROTOR BRAKE PANEL PACKAGE

** PART OF ROTOR BRAKE ACCUMULATOR

† MODIFIED BY AFC NO. 193

BLADES FOLDING LEGEND

- PRESSURE TO FOLD ROTARY WING HEAD
- RETURN
- PRESSURE TO POSITION ROTARY WING HEAD
- PRESSURE TO REVERSE BLADE ROTATION
- BYPASS
- PRESSURE FOR ROTOR BRAKE DURING MANUAL APPLICATION ONLY (AFTER ROTARY WING HEAD HAS BEEN POSITIONED)
- SUPPLY TO ROTOR BRAKE

EFFECTIVITY

BUNOS 149730 AND SUBSEQUENT

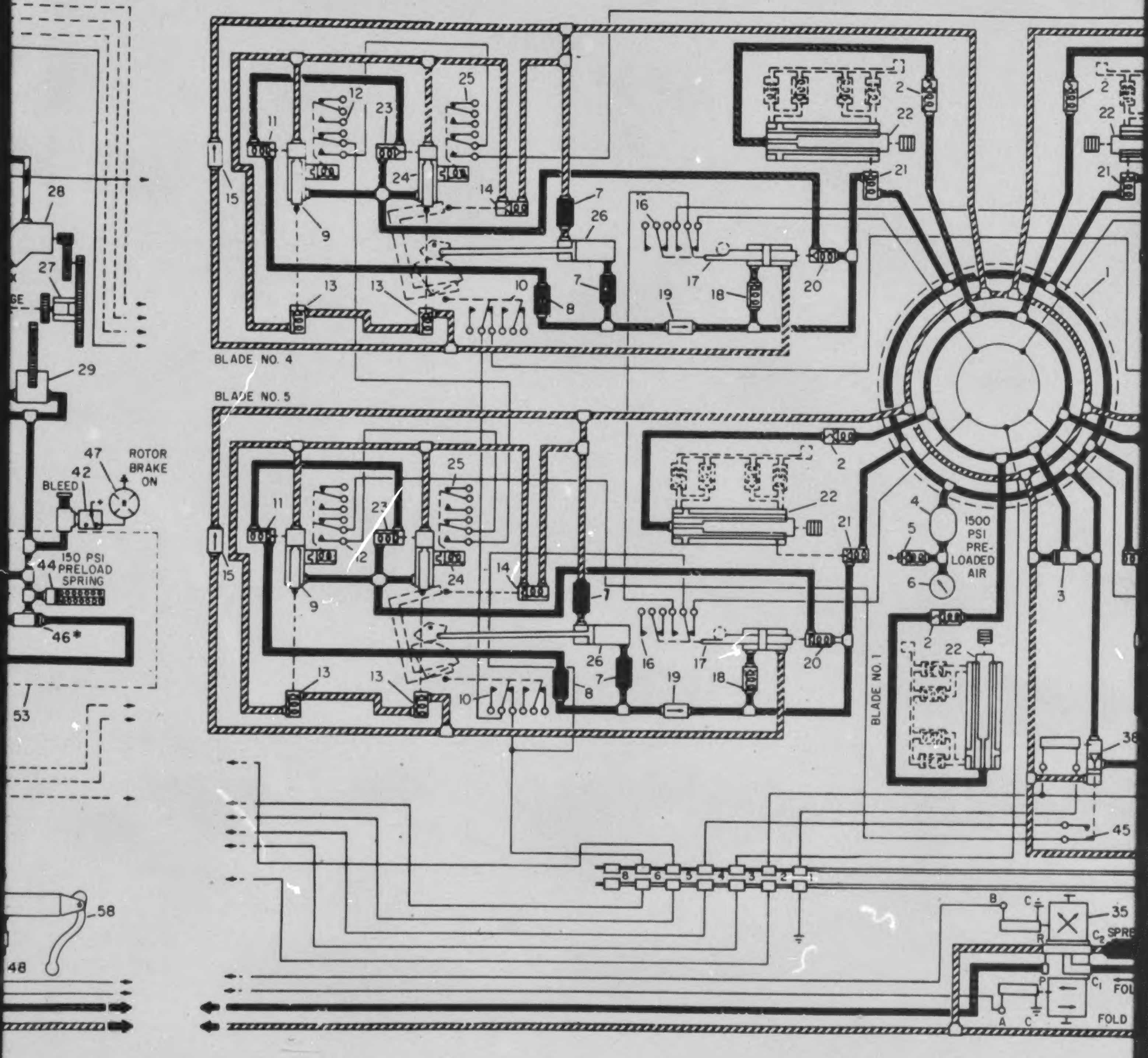
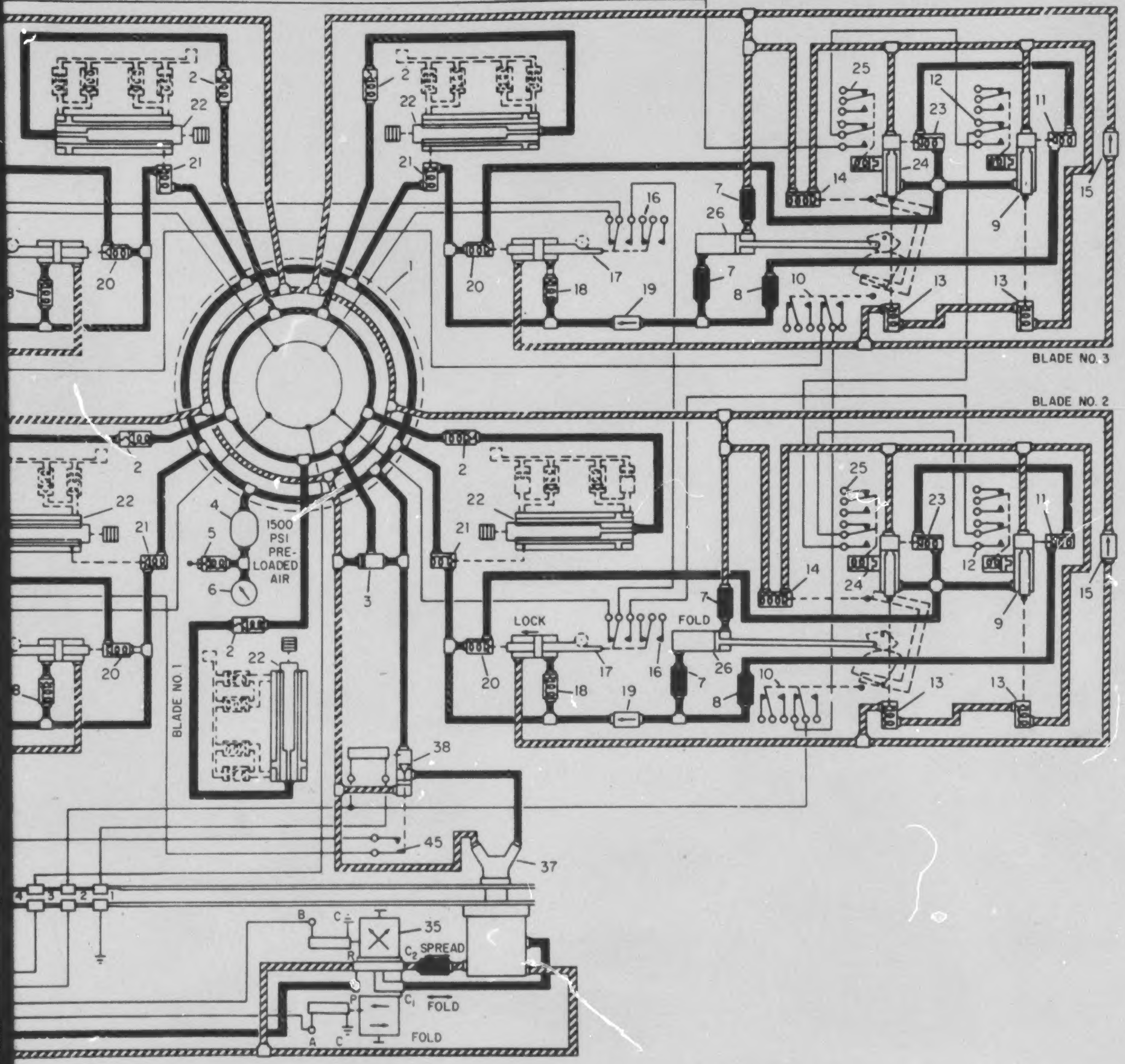

BLADE NO. 4
BLADE NO. 5
BLADE NO. 1
46*
ROTOR BRAKE ON
BLEED
150 PSI PRELOAD SPRING
1500 PSI PRE-LOADED AIR
GE
B
C
R
P
A
C_1
C_2
SPRE
FOL
FOLD

Figure 10-17.—


BLADE NO. 3
BLADE NO. 2
BLADE NO. 1
1500 PSI PRE-LOADED AIR
LOCK
FOLD
SPREAD
C_2
C_1
FOLD
FOLD
B
C
R
P
A
C
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
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19
20
21
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24
25
26
35
37
38
45

Figure 10-17.—Automatic blade folding system schematic (SH-3A).

216.207

seeking action of the governor by causing the servo valve to begin closing during acceleration or deceleration before the set speed is attained. The feedback signal is dissipated by equalization of pressure through the orifice.

The stability and response of the generator drive system as well as the motor are largely dependent on the action of the buffer assembly. The buffer orifice and spring sizes are matched to the peculiarities of the overall system such as pump characteristics, fluid volume, line lengths, and inertia and performance of the driven machine (generator).

MAINTENANCE

Maintenance of the generator drive system normally consists of servicing, testing and checking for proper operation, adjusting, troubleshooting, and removal and installation of system components, flexible line couplings, and other plumbing. Servicing and maintenance procedures and precautions are listed in the Maintenance Instructions Manual and respective 03 manuals and must be observed at all times to complete the procedures efficiently and safely. Particular attention should be given to cautions and warnings and specified quality assurance considerations.

AUTOMATIC BLADE FOLDING SYSTEM (SH-3A)

The rotary wing blades of the SH-3A helicopter are equipped with an automatic blade folding system, which allows folding of four of the five rotary wing blades from controls within the cockpit.

DESCRIPTION/OPERATION

The number 1 blade does not fold, but is automatically positioned over the tailpylon. The only hydraulic actuation of the No. 1 blade is damper positioning. The hydraulic portion of the system is used to position and fold the blades. The electrical portion provides the sequencing of operation of the various hydraulic components and acts to prevent accidental operation of the system. Warning and indicating lights indicate the status of the system at all times. Safe operation is maintained by a series of electrical interlocks.

Folding Operation

Blade folding operations are performed with the pylon locked in the flight position, No. 1 engine operating at 104 percent Nf (free turbine power speed), No. 2 fuel firewall valve closed, rotary wing head stopped, accessory drive switch in ACCESS DRIVE, safety valve switch OPEN, master switch ON, and blades switch at FOLD. Figure 10-17 illustrates the schematic diagram for the blade folding system of the SH-3A discussed in the following paragraphs. A majority of the electrical portion has been deleted for clarification while discussing system operation.

Hydraulic pressure from the utility hydraulic system is supplied at 3,000 psi and directed through the motor-operated safety valve (36, fig. 10-17). This pressure flows to the blade positioner control valve (32) and is directed to the blade positioner drive unit (27) for engagement with the rotor brake disc to turn the rotary wing shaft.

This action causes pressure to be directed through the blade rotation control valve (33) to the blade positioner hydraulic motor (28). The motor revolves the blade positioner, causing the rotation of the rotary wing head. When blade No. 1 is properly positioned aft, the blade positioner control valve is energized in the opposite direction, stopping positioning action and disengaging the blade positioner drive unit. Fluid is also directed to engage the rotor brake (29) at this time.

On the latest models of the SH-3A, the rotor brake is applied manually, the blade fold control valve (35) is energized, directing hydraulic pressure through the rotor coupling (37) to each damper-positioner, moving the blades against their autorotative stops. Mechanical action of positioning the blades actuates the damper-positioner sequence valves, which cause hydraulic fluid to actuate the control lock cylinders (17) locking the controls. With the rotor head controls locked, pressure is directed to the blade fold lock cylinders (9 and 24). The lockpins are retracted and fluid is directed to the blade fold cylinders.

The blade fold cylinders, figure 10-18, are located inside the sleeve spindles of blades 2, 3, 4, and 5. They connect to sector gears, which cause the folding action. The cylinders on blades No. 2 and 5 fold each blade to a 70.5 degree angle. On blades No. 3 and 4, the folding angle is 131 degrees. When they reach their respective angles, a microswitch illuminates the blades folded light in the cockpit. The lock valve (38) traps hydraulic fluid in the rotary wing head to keep the damper-positioners in the autorotative position and the blades in the folded position.

With the fold sequence completed, the SAFETY VALVE OPEN, FOLD PWR ON, NO. 1 BLADE POS, CONT LOCKPIN ADV, and BLADES FOLDED warning and indicating lights should all be illuminated.

NOTE: Cyclic control sticks may have to be moved slightly around neutral position to engage control lockpins. If excessive movement of cyclic stick is necessary, troubleshoot system for possible maladjustment.

Spreading Operation

The spreading operation requires conditions identical to the fold operation with the exception that the blades fold switch is at SPREAD. Pressure is directed through the motor-operated safety valve (36) and through the positioning unit pressure reducer (40) to the blade positioner drive unit to ensure disengagement of the rotor brake disc and engagement of the rotor brake (29).

With the rotor brake on and the blade fold valve energized, 3,000 psi hydraulic fluid is directed through the rotor coupling (37) to the damper-positioners (22), which position the blades against their autorotative stops; and to the blade fold cylinders. These cylinders actuate the gear sectors by retracing and spreading the blades. As the blades start to spread, the lock valve solenoid is deenergized, releasing trapped fluid in the rotary wing head.

When the blades are completely spread, hydraulic fluid is directed to the blade lock cylinders, engaging the blade lockpins. Engagement and locking of the blade lockpins cause the internal sequencing mechanism to direct pressure to the control lock cylinders, unlocking the controls. The spread sequence is completed and the FOLD PWR, BLADES SPREAD, and SAFETY VALVE OPEN warning and indicating lights should be illuminated.

Components

Hydraulic components of the blade folding system are conventional type solenoid-operated selector valves, check valves, pressure reducers and snubber, sequence valves, actuating cylinders, etc. Some of the components are peculiar to helicopter blade fold systems and are discussed briefly in the following paragraphs.

SAFETY VALVE.–The safety valve is a two-position, motor-operated selector valve which prevents hydraulic pressure from entering the blade fold system during flight. The motor provides a camming action to move the poppet valves within the selector valve. With the rotor stopped, electrical interlocks allow the safety valve to direct fluid to the blade folding system when the safety valve switch is placed in the OPEN position. In the CLOSED position, pressure is blocked at the pressure port and the system is vented through the lock valve to eliminate the possibility of damage to the system by thermal expansion of the hydraulic fluid. The safety valve will not close if the blade spread interlock relay malfunctions or if the blades are folded. The safety valve motor opens a limit switch and cuts electrical power to the motor when the safety valve reaches the fully open position.

BLADE POSITIONER DRIVE UNIT.–The drive unit is located on the upper surface of the main gearbox input cover and consists of a gear

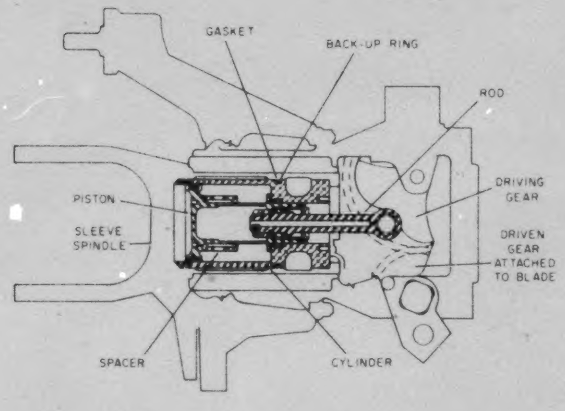

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Figure 10-18.–Blade fold cylinder.

train, a sequence valve, a filler plug, sight gage, and hydraulic motor. The gear train is rotated by the motor to turn the rotary wing head by running the rotor brake disc. The hydraulic disc motor operates only after the gear trian has been hydraulically positioned to engage the teeth of the rotor brake disc. Pressure is cut off to the blade rotation control valve and the motor by the sequence valve when the gear train has been actuated to disengage the rotor brake disc.

ROTOR COUPLING.–The rotor coupling is located at the bottom of the rotary wing shaft and serves to transfer hydraulic fluid to the rotary wing head for blade folding. Figure 10-19 illustrates a cross-sectional view of the coupling, which consists of a spindle that revolves with the rotary wing shaft, and a stationary housing connected to hydraulic lines of blade folding components. Hydraulic fluid is directed through the rotor coupling, then through the lock valve to the manifold (1, fig. 10-17), to the damper-positioner shuttle valve and the damper-positioner sequence valves.

CONTROL LOCK CYLINDER.–One lock cylinder is located on each horn assembly rotary wing head on blades 2, 3, 4, and 5. During the fold cycle, the control lock cylinders lock the flight controls after the blades have been positioned. During the spread cycle they unlock the controls. Microswitches within the housing of each cylinder are actuated and cause the CONT LOCKPIN ADV advisory light in the cockpit to illuminate. In event of hydraulic malfunction, the control lockpin may be operated manually by turning a sector gear bolt on the aft end of the cylinder. The sector bolt rotates gear teeth on the end of the actuating piston shaft.

BLADE FOLD ACCUMULATOR.–A blade fold accumulator is located inside of the rotary wing sleeve for blade No. 1. It is preloaded with 1,500 psi nitrogen pressure to maintain hydraulic pressure in the rotary wing head to keep the damper-positioners extended and the blades locked in the folded position. It also serves to compensate for expansion and contraction of the hydraulic fluid due to temperature changes and dampens out pressure surges during fold and spread cycles.

MAINTENANCE

Maintenance of the blade fold system and components consists of periodic inspection, lubrication, operational testing, troubleshooting, alignment and adjustment, and removal and installation of components. Parts replacement and cure date kits are available for intermediate

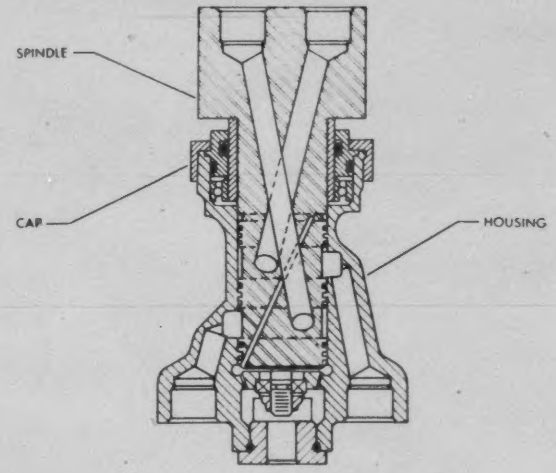

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Figure 10-19.–Rotor coupling.

level repair of defective components. Prior to removal of any component, the blades should be stowed to prevent their damage. Whenever any component of the system has been repaired or replaced, the entire hydraulic portion of the system should be operationally tested to ensure proper sequence of operation.

Hydraulic Testing

Prior to testing the hydraulic portion of the blade fold system, the electrical portion should be tested in accordance with the Maintenance Instructions Manual. Hydraulic testing consists of the following steps:

Charge the air accumulator with 1,500 psi of nitrogen with blades spread.

Connect a source of external hydraulic power to the utility, primary, and auxiliary hydraulic systems. Set pressure to 3,000 psi at approximately 3 gallons per minute for the utility system and 1,500 psi for the primary and auxiliary servo hydraulic systems.

Position the ACCESSORY DRIVE switch to ACCESS DR. The accessory drive light will illuminate.

At the start of the testing, ensure that PRI SERVO PRESS, AUX SERVO PRESS, ACCESSORY DRIVE, ROTOR BRAKE ON, and CHECK BLADE FOLD lights will illuminate. The ACCESSORY DRIVE, FLIGHT POS, BLADES SPREAD, EXT PWR ON, PRI SERVO PRESS and AUX SERVO PRESS lights should be illuminated.

Visually check that all lockpins are disengaged.

Manually rotate the rotary head until the leading edge of the No. 1 blade is in the aft position, and engage the rotor brake. The rotor brake pressure gage should read a minimum of 320 psi. Check that the rotor brake light comes on.

NOTE: On helicopters modified by AFC No. 293, with rotor brake pressure still on, energize (on overhead control panel) HOIST CONT CIRCUIT BREAKER, deenergize HOIST SHEAR circuit breaker, position HOIST CREW–OFF–PILOT switch to CREW, and then temporarily position switch to DAVIT CONTROL panel to OUT. Davit should not move. If davit starts to move, immediately release switch to center (off) position to stop davit action, and investigate malfunction in rescue hoist davit system. Following this procedure, restore switches and circuit breakers to their former positions.

Place the collective pitch stick in full low position and the cyclic pitch stick in neutral. Visually examine each control lock cylinder to ensure that pins are aligned with their holes.

When the controls are positioned, trip the FOLD manual override on the blade fold control valve and hold it in this position. No action should result. Release the override.

Position the SAFETY VALVE switch to OPEN. Check that the SAFETY VALVE OPEN light illuminates. Trip the manual override again. The dampers will position, control lockpins will engage, blade lockpins will disengage, blades will fold, and PRI SERVO PRESS light will go off.

CAUTION: Ensure that the path of the blades is clear before tripping the manual override. The cyclic control stick may have to be moved slightly around neutral to engage the control lockpins.

Check the lights on the blade fold panel. CONT LOCKPINS ADV, BLADES FOLDED, CHECK BLADE FOLD, SAFETY VALVE OPEN, AND ACCESS DR ON lights should be lighted and the BLADES SPREAD light off.

Trip the manual override button to SPREAD. Blades will spread, lockpins will engage, and control lockpins will disengage. The BLADES SPREAD and CHECK BLADE FOLD lights will illuminate.

Position the SAFETY VALVE switch to CLOSED. Check that the SAFETY VALVE OPEN and CHECK BLADE FOLD lights go off within 1 1/2 seconds and that the FLIGHT POS light illuminates.

Release the rotor brake and ensure that the ROTOR BRAKE ON light goes off. Manually reposition the number 1 blade off to the right of the helicopter centerline.

Position the safety valve switch to OPEN and the master switch to ON. Check that SAFETY VALVE OPEN and FOLD PWR ON lights illuminate. Check that the ACCESSORY DR ON light is illuminated and the No. 2 engine FIREWALL VALVE switch is in the CLOSED position. The rotor brake should disengage automatically and hydraulic pressure should disengage the blade positioner drive unit from the rotor brake disc. The final movements of blade positioning may result in a position hunting motion or chatter. If this chatter is sustained for more than three seconds, investigate the cause.

Position the blades fold switch to FOLD. The No. 1 BLADE POSITION light will illuminate. Apply the rotor brake manually. Damper-positioners will position, control lockpins will engage, CONT LOCKPIN ADV light will illuminate, blade lockpins will retract, BLADES SPREAD light will go off, and BLADES FOLDED and CHECK BLADE FOLD lights will illuminate.

NOTE: Automatic fold cycle time is approximately 30 seconds for the rotary wing positioning, 5 seconds for damper positioning, and 27 to 41 seconds for blade folding.

Check that the accumulator gage on blade No. 1 sleeve spindle maintains 3,000 psi, damper-positioners remain in fully extended or auto-rotative position, and blades remain folded.

Position the blade fold switch to SPREAD and check the reversing of operation. When the BLADES SPREAD light illuminates, position the safety valve switch to CLOSED. SAFETY VALVE OPEN and FOLD PWR ON lights should go out. Position MASTER and BLADE FOLD switches to OFF. CHECK BLADE FOLD light will go off and FLIGHT POS light will illuminate. Visually check control lockpins for disengagement.

The No. 1 blade should then be moved to the left of the helicopter centerline and the automatic folding sequence repeated. Following the hydraulic testing, inspect all components for external leakage.

CARGO DOORS AND RAMP ACTUATING SYSTEM

The operation of opening, closing, locking, and unlocking of the cargo doors and ramp of the C-2 and providing cockpit indications of these operations are performed by the cargo doors and ramp actuating system, side doors lift linkage system, ramp lock system, center door lock system, and the cargo doors and ramp lock indicating system. Figure 10-20 illustrates the cargo doors and ramp actuating system components.

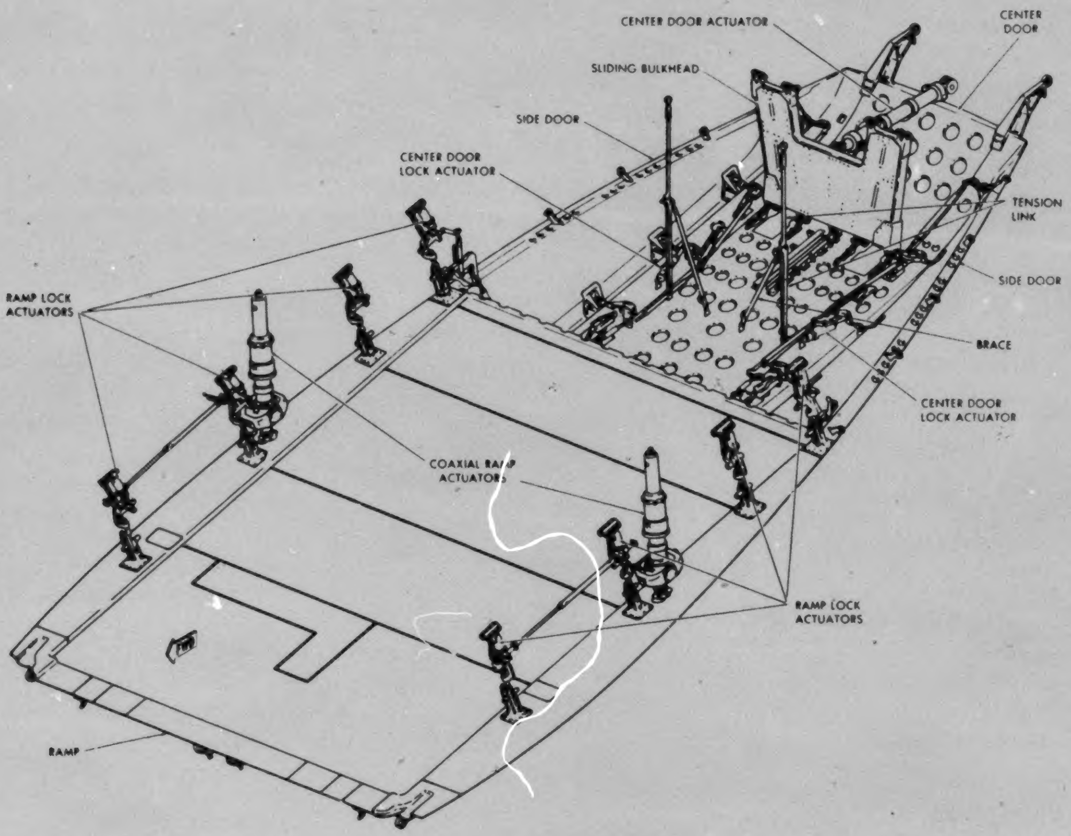
DESCRIPTION

Power from the combined hydraulic power system is used to operate hydraulic actuating cylinders that open, close, lock, and unlock the center door, two side doors, and the ramp which makes up the cargo compartment access to accommodate loading and unloading operations at the rear of the aircraft. Timer valves, check valves, priority valves, and flow regulators provide the necessary sequencing of events during the operation.

Controls for opening and closing the doors and ramp may be actuated electrically from the cockpit or manually at the cargo door and ramp selector valve located in the aft starboard section of the fuselage and accessible from inside or outside the aircraft. The ramp loading selector valve is located aft of the cargo door and ramp selector valve and permits further lowering of the ramp from the ground level control station only. Electrical interlocks on the access doors disable the pilot's control switch power supply when the access doors are open.

Activating the cargo door and ramp selector valve from the control switch in the cockpit or manually from the aft control station first releases the center door locks, then opens the center door. The ramp uplocks are released, and the ramp opens. The right and left aftermost ramp lock actuators additionally actuate mechanical linkage which opens the side doors. The ramp opens to a level position and stops, but can be further lowered to contact the ground by positioning the ramp loading selector valve to further extend the coaxial ramp actuator. This operation cannot be controlled from the cockpit.

The center door and ramp actuators have speed-limiting flow regulators in the extend and retract ports and priority valves in the coaxial ramp actuator extend lines to provide proper ball lock release pressure before allowing the


CENTER DOOR ACTUATOR
CENTER DOOR
SLIDING BULKHEAD
SIDE DOOR
CENTER DOOR LOCK ACTUATOR
TENSION LINK
RAMP LOCK ACTUATORS
SIDE DOOR
BRACE
CENTER DOOR LOCK ACTUATOR
COAXIAL RAMP ACTUATORS
RAMP LOCK ACTUATORS
RAMP

216.210

Figure 10-20.—Cargo doors and ramp actuating system components.

coaxial ramp actuator to lower from level to ground position through operation of the ramp loading selector valve.

The ramp may be raised from the ground to level position by manually repositioning the ramp loading selector valve. It may be raised from ground to the fully closed position by electrical control from the cockpit or manual control of the cargo door and ramp selector valve, which would pressure actuate the ramp loading selector valve to the level position.

On selecting the CLOSE position, the ramp lock actuators are extended, arming the locks for subsequent engagement with the uplock rollers. When the ramp closes, the ramp lock actuators are triggered and extended to the locked condition. The aftermost ramp lock actuators (through their mechanical linkage) close the side doors. Timer valves, actuated by the final closing motion of the side doors, allow hydraulic pressure to the cargo center door actuator, arming the center door uplocks. The center door closes and locks, also locking the ramp and side doors together.

If electrical power is not available, the open and closing cycles can be controlled manually. If hydraulic power is not available, the hand pump in the cockpit may be used to provide pressure by positioning the rotary selector valve to AUX and operating the pump.

Emergency pneumatic operation to unlock and open the center door only is available through a compressed nitrogen bottle equipped with a manual control valve which, when actuated, allows pressure to be directed to the center door dump valve and shuttle valves, the center door lock actuators, and the center door actuator, thus opening the center door.

The cargo center door is fitted with two identical tension link installations located at the forward end of the door and attached to the structure above the door. Each installation consists of an upper and lower tension link, hinged at midpoint to allow for forward folding during door opening, and a brace for lateral stability. The tension links, in conjunction with the sliding bulkhead, shown in figure 10-20, prevent excessive loading against the cargo side doors and ramp when the aircraft is pressurized.

OPERATION

WARNING: Make sure that all personnel and equipment are clear of the operation areas of the cargo doors and ramp both inside and outside the aircraft. All steps must be performed in sequence. Do not attempt to reverse the door opening or closing motion until the door has come to a complete stop.

The opening cycle of the cargo doors and ramp is initiated by electrically or manually causing the cargo doors and ramp selector valve to be positioned to the OPEN position. The selector valve then ports hydraulic pressure to the shuttle valves, which are an integral part of the center door lock actuators. The center door lock actuators retract, releasing the center door locks. Pressure is then directed through a flow regulator to the standpipe section of the cargo center door actuator, causing it to extend. It is held in the extended position by its ball lock feature.

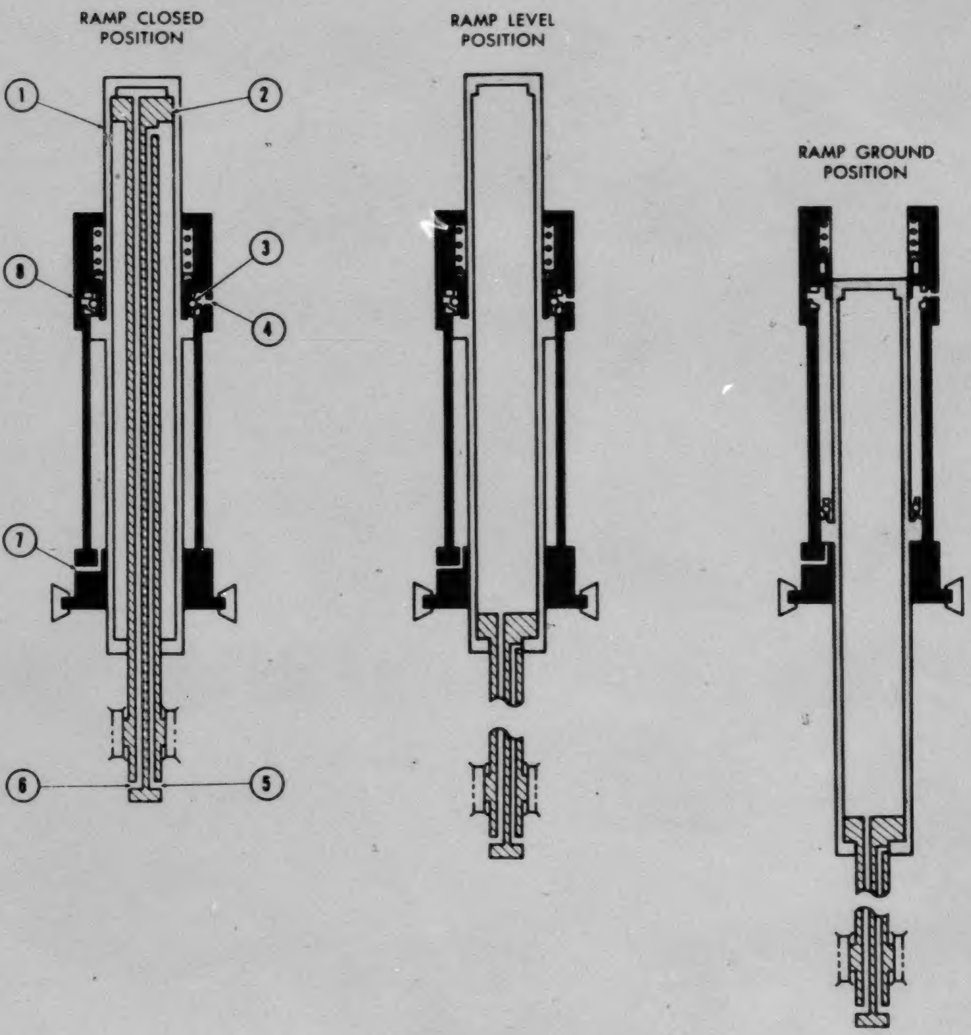
During the final opening movement of the center door, a timer valve is mechanically actuated and directs pressure to the retract ports of the eight ramp lock actuators and through flow regulators to the coaxial ramp actuators' inner cylinder extend port, figure 10-21. The ramp lock actuators retract, unlocking the ramp, with the two aft actuators simultaneously opening the two side doors. The flow regulators in the retract lines of the two aft ramp lock actuators slow the action of the side doors. Relief valves are installed to reduce hydraulic shock. A pressure line tap provides system pressure through the flow regulators to the coaxial ramp actuators' inner cylinder extend port.

System pressure is also directed from the cargo doors and ramp selector valve through a check valve and flow regulator to the coaxial ramp actuators inner cylinder retract port. The inner cylinder piston area on the extend side is larger than the piston area on the retract side; therefore, the force differential, plus the weight of the ramp, lowers the ramp to the level position.

As the inner piston extends, the inner cylinder retract ports direct displaced fluid through the flow regulators and check valve back into the combined system pressure lines. The ramp stops at the level position due to bottoming of the piston in the inner cylinder. The ramp may be positioned at any intermediate position between level and ground by manual use of the ramp loading selector valve.

When positioned to RAMP GROUND, this valve directs system pressure to both the extend and retract ports of the coaxial ramp actuators outer cylinder. The piston area that both ports serve is the same, resulting in hydraulic equilibrium. The weight of the ramp then lowers the ramp to the desired position. When the ramp loading selector valve is placed at RAMP LEVEL, system pressure is directed to the retract port of the outer cylinder, bringing the ramp to level. The ramp is retained at the level position by the ball lock feature incorporated in the outer cylinder of the coaxial ramp actuator.

The closing cycle is initiated by electrically or manually causing the cargo doors and ramp selector valve to be positioned to the CLOSE position. In the CLOSE position, pressure is directed from the selector valve to the eight ramp lock actuators, extending them and arming the uplocks for subsequent engagement with the uplock rollers on the ramp. The two aftermost


RAMP CLOSED POSITION

RAMP LEVEL POSITION

RAMP GROUND POSITION

1. Inner cylinder.
2. Inner cylinder piston.
3. Lock ball.
4. Outer cylinder extend port.
5. Inner cylinder retract port.
6. Inner cylinder extend port.
7. Outer cylinder retract port.
8. Outer cylinder.

216.211

Figure 10-21.—Coaxial ramp actuator.

ramp lock actuators simultaneously close the side doors through the side door lift linkage system. Pressure is also ported to the ramp load selector valve, ensuring that it is in the ramp level position. If the ramp is in the ground or deck position, it is hydraulically actuated to the ramp level position.

The final closing movement of the side doors actuates the side door timer valves, directing pressure through the center door dump valve to the center door lock actuators, arming them for engagement with the side door and ramp aft uplock rollers. Pressure is also ported to the retract port of the center door actuator, closing the center door and completing the closing cycle.

COMPONENTS

Some of the major cargo door and ramp actuating system components are discussed in the following paragraphs.

Cargo Door and Ramp Selector Valve

The cargo doors and ramp selector valve illustrated in figure 10-22 is a solenoid-operated, four-way, three-position spool type valve. It is detented in the selected position when electrically controlled. The manual control handle is not detented and is spring-loaded to NEUTRAL. Electrical operation of the valve energizes solenoid A or B to direct combined system pressure to the door and ramp system components. In the electrically or manually NEUTRAL position, both open and close ports are blocked, except for a small interport bleed passage which prevents ramp creepage. NEUTRAL positioning of the valve will stop the opening or closing cycle at any point in its sequence of operation.

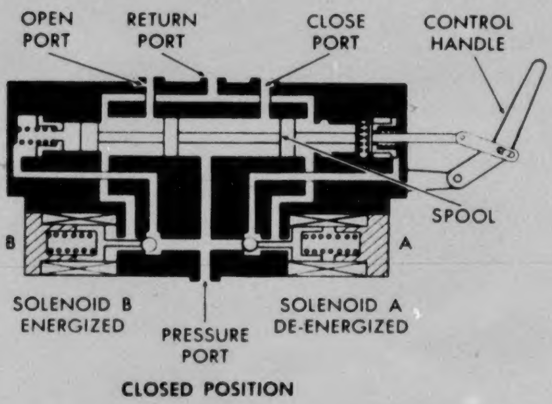


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Figure 10-22.—Cargo doors and ramp selector valve.

Ramp Loading Selector Valve

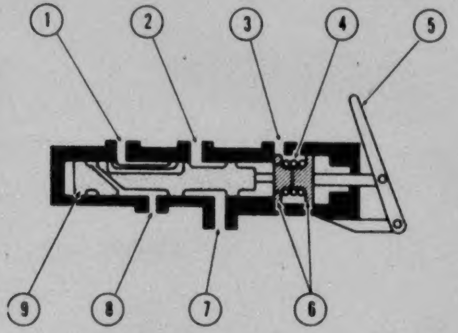
The ramp loading selector valve illustrated in figure 10-23 is a five-way, three-position slide valve with manual selection. It is spring-loaded to the NEUTRAL position and can be manually or pressure actuated to the RAMP LEVEL position.

Positioning of the handle in either the RAMP LEVEL or RAMP GROUND position directs pressure to the outer cylinder of the coaxial ramp actuator. Releasing the handle during the raising or lowering cycle will maintain the ramp in any intermediate position between level and ground.

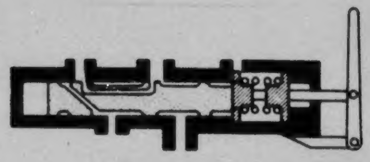
In NEUTRAL, the pressure port is blocked and the extend port is open to return with a small bleed open to the retract port. In the RAMP GROUND position, the spool is positioned to open the extend and retract ports to pressure, allowing the weight of the ramp alone to slowly lower the ramp without causing damage.

Coaxial Ramp Actuator

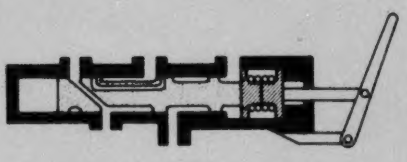
The coaxial ramp actuator is illustrated in figure 10-21. Each actuator consists of an inner cylinder, the piston of which is attached to the ramp. The entire inner cylinder assembly acts as the piston for the outer cylinder, which is secured to the aircraft structure. The inner cylinder extends and retracts to lower the ramp to the ground level position and the fully closed position. The outer cylinder extends to further lower the ramp from level to the ground or deck position and retracts to raise the ramp back to the level position.



RAMP LEVEL POSITION



NEUTRAL POSITION



RAMP GROUND POSITION

1. Retract port.
2. Extend port.
3. Actuating port.
4. Spring.
5. Control handle.
6. Spring guides.
7. Return port.
8. Pressure port.
9. Spool.

216.213

Figure 10-23.—Ramp loading selector valve.

When RAMP OPEN is selected, pressure is simultaneously applied to both the inner cylinder extend and retract ports. Differential piston area causes a force differential, and the piston extends. When RAMP GROUND is selected, pressure is directed to the outer cylinder extend port and the ball lock securing the entire inner cylinder assembly to the outer cylinder is released. Pressure is simultaneously applied to the outer cylinder retract port and, since piston areas are equal, a balanced condition occurs.

In this hydraulic equilibrium condition, the weight of the ramp causes the necessary imbalance required to lower itself to the ground or deck position. When RAMP LEVEL is selected, the extend port is open to return and the retract pressure acts on the entire inner cylinder assembly, returning it to the ball locked condition. When RAMP CLOSED is selected, the inner cylinder piston retracts, closing the ramp.

Ramp Lock Actuators

The eight ramp lock actuators are conventional double-acting type cylinders that release the ramp locks when retracting and arm the locks on extension.

Cargo Center Door Actuator

The cargo center door actuator is a three-port, double-acting cylinder with hydraulic extension through standpipe (piston shaft) feed, and a ball lock mechanism that locks the cylinder in the extended position. The third port provides for pneumatic extension. The extension stroke opens the center door and locks it. The retract stroke closes the door.

Center Door Lock Actuator

The two center door lock actuators are conventional double-acting cylinders with an integral shuttle valve serving the retract port. The extension stroke locks the side and center doors in the closed position. Retraction releases the locks and may be accomplished using normal system pressure or by emergency pneumatic operation, which shifts the shuttle valve and pneumatically unlocks the door, then extends the center door actuator.

MAINTENANCE

Organizational level maintenance of the cargo doors and ramp actuating system normally includes operational testing, malfunction analysis using system schematics and troubleshooting charts, lubrication, removal and

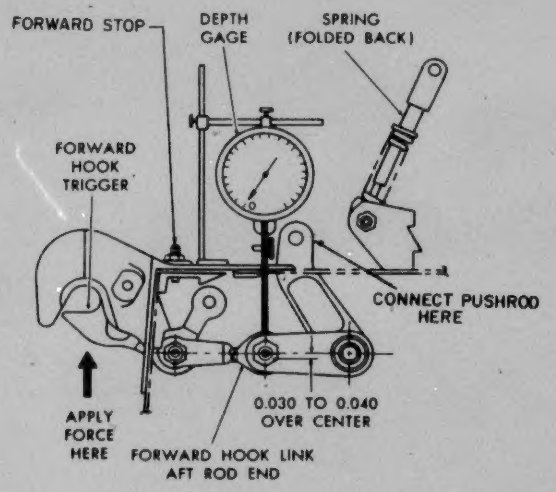


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Figure 10-24.–Measuring for proper overcenter locking.

installation of components and associated plumbing, and rigging and adjustment of actuator rod ends, linkages, and cables.

Adjustment

Adjustment of linkages is largely dependent on measuring specific distances at designated points with a graduated scale,. but some Maintenance Instructions Manuals require the use of special tools such as the dial indicating depth gage illustrated in figure 10-24. This gage is being used to check for proper overcenter locking. In this example, the depth gage, graduated in thousandths, is set at zero with the plunger on the upper surface of the forward hook link aft rod end and pressure applied to hold the forward hook trigger firmly in the locked position.

A simulated roller is then placed in the lock and the connecting pushrod adjusted and connected to cause the forward hook trigger to hold the simulated roller firmly without binding. The depth gage should read between 0.030 to 0.040 inch to provide proper overcenter locking. If the dimension is not within tolerance, the connecting pushrod and the forward hook link rod end must be readjusted.

The aft and forward stops (aft not shown) are then adjusted, and the spring link is connected to the forward hook trigger crank. With a minimum of 2,400 psi hydraulic pressure on the lock actuator, and the forward hook trigger open, the simulated lock roller is forced into the forward hook opening, and the force required to trip the trigger upward is checked, using a spring scale. As soon as the trigger has been tripped, the lock actuator can extend.

Other methods recommended in Maintenance Instructions Manuals include using a straightedge and a shim or feeler gage, as illustrated in figure 10-25. This method can be used to measure overcenter or stop clearance.

In figure 10-26, a graduated scale is used to determine the distance between the actual centerline of the connecting linkages and the overcenter pivot attaching bolt.

Intermediate level repair of cargo door and ramp system components consists of replacement of miscellaneous repair parts and cure date-kit items, such as sealing devices, packings, backup rings, and wipers, inspection of components, including internal mechanisms, and static and functional testing following reassembly.

The quality assurance considerations for both levels of maintenance are indicated by underlines steps that must be inspected before

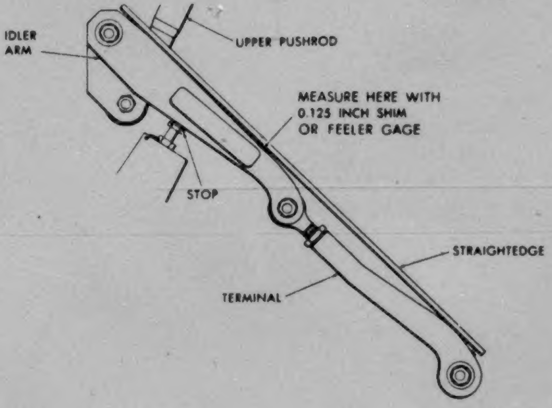

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Figure 10-25.–Side door linkage stop adjustment.

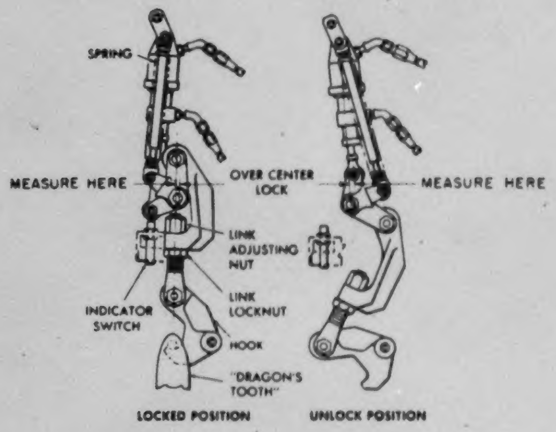

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Figure 10-26.—Measuring ramp locking and unlocking overcenter linkage.

further repair can commence. No maintenance task is considered completed until the accompanying paperwork is completed.

MISCELLANEOUS HYDRAULICALLY OPERATED ACTUATING SYSTEMS

There are numerous miscellaneous hydraulically actuated systems found in the many aircraft within the naval inventory. Descriptions and theory of operation for some of these miscellaneous systems are covered in the following paragraphs. Troubleshooting and maintenance of these systems parallel the procedures previously discussed for other electrically or manually controlled and hydraulically actuated systems.

RADOME OPEN/CLOSE SYSTEM (A-6)

The radome system in the A-6 provides a means of raising, lowering, and holding the radome open for access to the electronic equipment and other components located on the forward fuselage bulkhead. It is powered by the auxiliary power hydraulic system as illustrated in figure 10-27.

The radome is raised or lowered by a two-way hydraulic cylinder. The radome selector valve is located in the nosewheel well and is spring-loaded to the NEUTRAL position. A thermal relief valve is incorporated to relieve excessive pressure caused by thermal expansion. It is located downstream of the selector valve and is able to function whenever the radome is closed and the selector valve is in NEUTRAL.

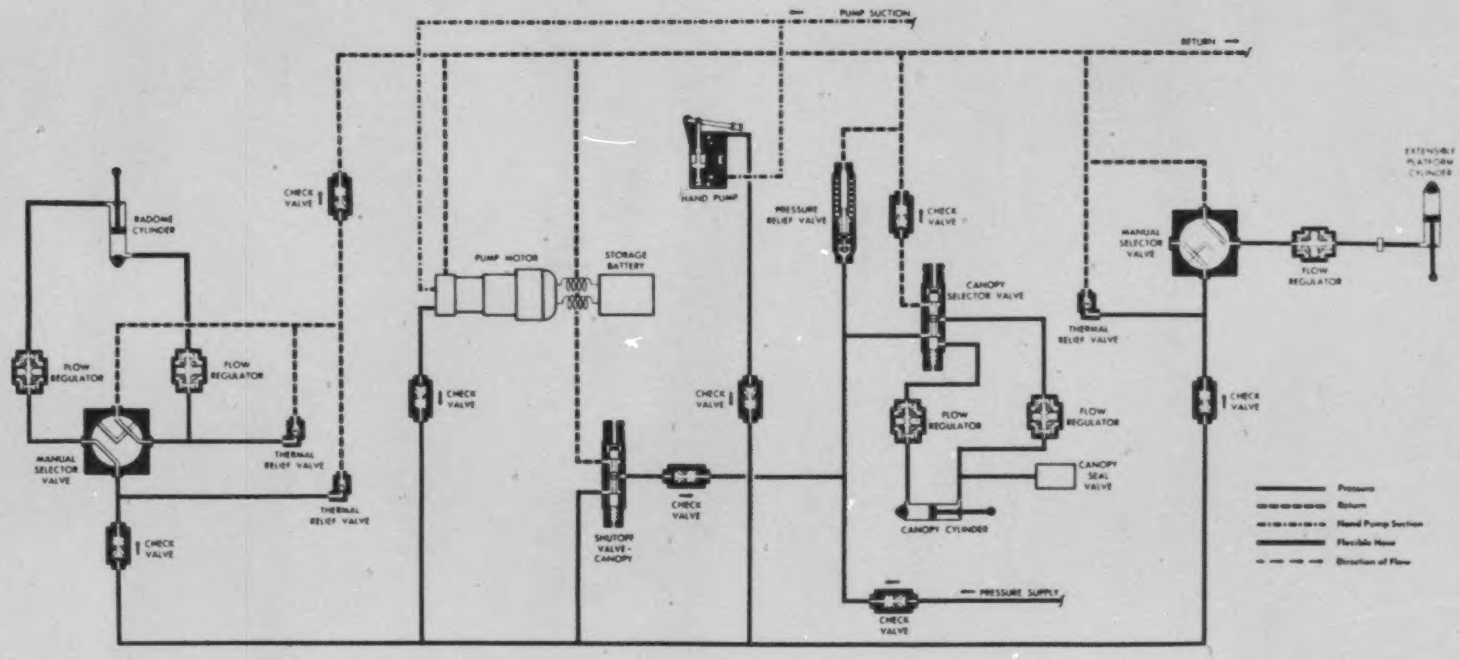
CAUTION: The radome should not be opened with wind above 30 knots.

Prior to actuating the auxiliary hydraulic power system, ensure that the canopy selector handle is in a position corresponding to the position of the canopy and that the radome and airborne equipment door selector controls correspond to static positions of the radome and door or are in neutral detent, as applicable. Jury struts should be installed to keep the radome open and prevent injury to personnel.

With the radome latches on each side of the radome open and the two bolts on each side of the radome withdrawn from their holes the radome is ready to open. Placing or holding the selector control at OPEN and stroking the hand pump or depressing the AUX hydraulic pump motor switch port pressure through the selector valve, to the flow regulator, and to the extending end of the radome actuating cylinder.

The rod end of the cylinder is attached to a torque tube on the radome, and its extended piston rotates the tube to raise the radome. Return fluid from the cylinder is routed through the flow regulator and selector valve to return. On older model A-6s, placing the selector valve at NEUTRAL opens the open and close ports to return and blocks fluid at the pressure port. On models with the spring-loaded selector valve, the cylinder is ported to return and the pressure port is blocked. This permits other systems powered by the auxiliary hydraulic system to be operated without pressurizing the radome system.

Removing the jury struts and placing or holding the radome selector valve at the CLOSED position ports pressure from the hand pump or the auxiliary hydraulic pump through the selector valve and flow regulator to the retract end of the actuating cylinder. To stop the radome during lowering operation, the selector valve can be placed at OPEN. On the


PUMP SUCTION
RETURN
EXTENSIBLE PLATFORM CYLINDER
RADOME CYLINDER
CHECK VALVE
PUMP MOTOR
STORAGE BATTERY
HAND PUMP
PRESSURE RELIEF VALVE
CHECK VALVE
CANOPY SELECTOR VALVE
MANUAL SELECTOR VALVE
FLOW REGULATOR
THERMAL RELIEF VALVE
FLOW REGULATOR
FLOW REGULATOR
CHECK VALVE
CHECK VALVE
FLOW REGULATOR
FLOW REGULATOR
CHECK VALVE
MANUAL SELECTOR VALVE
THERMAL RELIEF VALVE
CANOPY SEAL VALVE
THERMAL RELIEF VALVE
CHECK VALVE
SHUTOFF VALVE - CANOPY
CANOPY CYLINDER
CHECK VALVE
CHECK VALVE
PRESSURE SUPPLY
Pressure
Return
Hand Pump Suction
Flexible Hose
Direction of Flow

216.217

Figure 10-27.—Auxiliary hydraulic system (A-6).

spring-loaded to neutral type, releasing the handle will stop movement.

When the radome is closed, the fuselage bolts are loosely installed, the latches on each side of the radome are closed, then the bolts tightened. If the holes in the radome do not line up with the fuselage holes, the hand pump or AUX pump is operated with the selector valve at the CLOSED position until the radome is fully closed and the holes aligned.

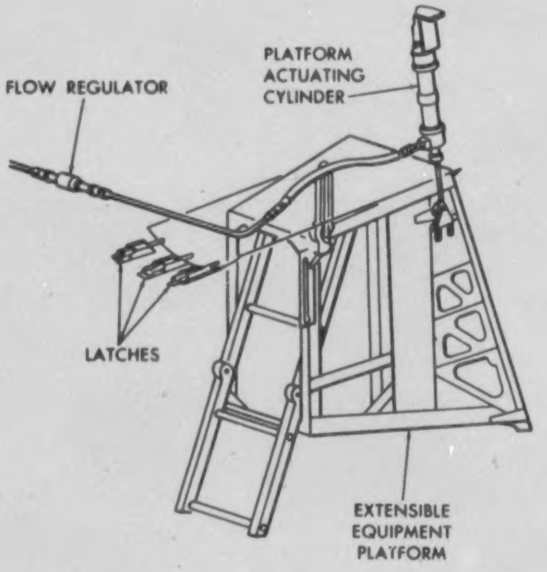
EQUIPMENT PLATFORM SYSTEM (A-6)

The extensible equipment platform system provides a means of raising and lowering the extensible platform for access to electronic equipment and other aft fuselage equipment. The system consists of a selector valve, actuating cylinder, flow regulator, thermal relief valve, and check valves. The platform illustrated in figure 10-28 is secured to the fuselage by hinges located at its aft end. The platform is supported by three latch pins (located at the forward end) when in the retracted position, and by two straps when extended. The lowering operation is accomplished by gravity, and the platform is raised by the single-acting hydraulic cylinder.

CAUTION: Prior to operating the extensible platform and the auxiliary hydraulic system ensure that the canopy switch is selected OPEN. Ensure that the manual canopy handle position corresponds to the static position of the canopy. Also, ensure that the radome and equipment door selector controls correspond to their static positions or are in neutral detent positions. The equipment door is extremely heavy and when imporperly lowered could cause personnel injury and/or equipment damage.

The lowering operation consists of placing or holding the equipment door selector control at RETRACT and operating either the hand pump or auxiliary pump to raise the platform and take the weight off the latch pins. The three latch pins are then opened and the selector moved to EXTEND. The platform will drop until the safety hook (located on the centerline of the platform at the forward edge) engages with its stop on the fuselage.

The selector may then be placed at RETRACT and the hand pump stroked or the auxiliary pump switch depressed to take the weight off the safety hook. The safety hook is held aft and the selector placed or held at EXTEND until the weight of the platform drops it to the fully extended position.



216.218

Figure 10-28.—Extensible equipment platform.

The platform can be stopped at intermediate positions by releasing the selector control or manually placing the selector control at RETRACT. During the downward movement of the door, fluid is forced from the retract side of the actuating cylinder through the flow regulator, the selector valve, and back to return. The flow regulator slows the motion of the platform to prevent damage.

The raising operation is performed by placing or holding the selector control in RETRACT, porting hydraulic pressure from the hand pump or the electric-motor-driven auxiliary pump, through the selector valve, and flow regulator to the retracting end of the actuating cylinder. When the platform is fully raised, the three latches are closed to lock the platform in position. On older model A-6s, the selector handle must be manually placed in the NEUTRAL position. If the hand pump is used to operate this system, the handle should be stowed immediately after use. Temporarily placing it on the nose landing gear linkage is a sure route to causing landing gear damage or loss of the handle.

CANOPY SYSTEM (A-6)

An example of a hydraulically operated canopy system is that incorporated in the A-6, Grumman Aircraft Engineering Corporation's attack bomber. The entire system is hydraulically operated except for the jettison device. Early versions of the A-6 incorporated an electrical jettison, while later versions employ the pneumatic jettison concept.

Personnel working on the hydraulic portion of the canopy system must ensure that the jettison portion has been dearmed and safety pins for the seat and canopy systems are installed. Hydraulic power for operation of the system is furnished by the combined hydraulic system, or the auxiliary hydraulic system as illustrated in figure 10-27.

Operation

Hydraulic flow to open or close the canopy is controlled through a selector valve located in the nosewheel well under the cockpit. The selector valve may be operated either electrically or manually. The canopy is normally operated by the canopy switch on the pilot's instrument panel. This switch electrically controls the selector valve whenever the engines are operating or external electrical power is connected.

When external electrical power is applied to the aircraft, the primary canopy system is inactivated and the battery in the auxiliary system is bypassed. When external hydraulic power is applied, the canopy can be opened or closed by manually positioning the canopy selector valve. The manual selector handle is located on the pilot's control stick pedestal and is mechanically linked through the floor to the canopy selector valve. To open the canopy, pull up; to close canopy, push down.

CAUTION: On older version A-6s, the canopy switch in the cockpit should be selected OPEN at all times during performance of ground maintenance. The manual canopy selector handle position should correspond to the position of the canopy.

On later version A-6s, the canopy selector valve is spring-loaded to the NEUTRAL position. The canopy switch is also spring-loaded to NEUTRAL and must be held in the OPEN or CLOSED position for canopy operation. These features were added to later versions as safety precautions to prevent personnel injury due to unwanted closing of the canopy. A guard is installed next to the manual selector to prevent personnel from inadvertently stepping on or otherwise depressing the handle and closing the canopy without the expressed desire to do so.

The auxiliary hydraulic power system is used for ground operation whenever the engines are shut down and the weight is on the wheels. Hydraulic pressure is supplied by an electrically driven hydraulic pump or the hand pump. The brake accumulator is also charged whenever the auxiliary system is operated.

Whenever the selector valve is selected to the CLOSED position, hydraulic pressure from either the combined (both engines) hydraulic system or the auxiliary system flows through the selector valve into the canopy closed line. Pressure is delivered through a flow regulator to the rod end of the actuating cylinder, causing the piston and rod to retract, closing the canopy. Opening of the canopy is the reverse of the closing operation.

An electrically operated shutoff valve prevents the radome and extensible platform systems from being pressurized during auxiliary canopy operation from the nosewheel well. A second shutoff valve prevents the canopy system from being pressurized when the radome or platform systems are in operation. When either of the auxiliary canopy control switches located in the boarding ladder wells are actuated, the auxiliary hydraulic pump motor and the desired solenoid of the canopy selector valve are energized simultaneously. No manual selection is required.

Canopy Seal Operation

As the canopy nears the fully closed position, the sliding structure mechanically cocks the canopy seal control valve, which permits engine bleed air to pass through the valve and inflate the canopy seal. When the canopy switch is selected to OPEN, hydraulic pressure flows through the canopy open line to the canopy seal control valve and hydraulically trips the seal valve, dumping the seal pressure and allowing the seal to deflate. Pressure in the canopy open line continues its flow through a flow regulator to the extend end of the canopy cylinder, causing it to extend and open the canopy.

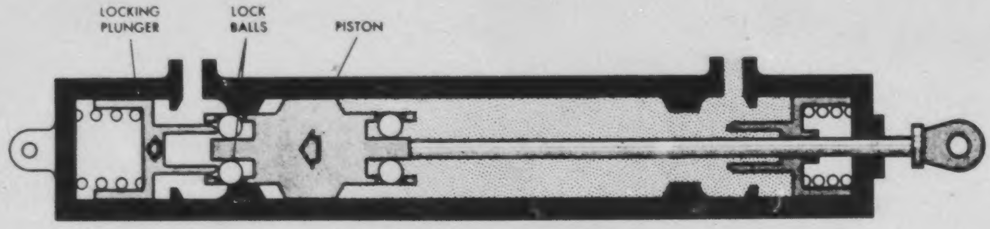
Canopy Actuating Cylinder

The double-acting, ball-lock type canopy actuating cylinder is illustrated in figure 10-29. For purposes of clarifying cylinder construction and operation, the jettison sequence is included. The piston rod (jettison sleeve) terminal end is attached to the underside of the sliding canopy structure, and the backhead end is attached to the fuselage structure. A locking mechanism at each end of the cylinder retains the piston in either the open or closed position until the sequence of fluid flow to the cylinder is reversed. The canopy jettison system is an integral portion of the cylinder.

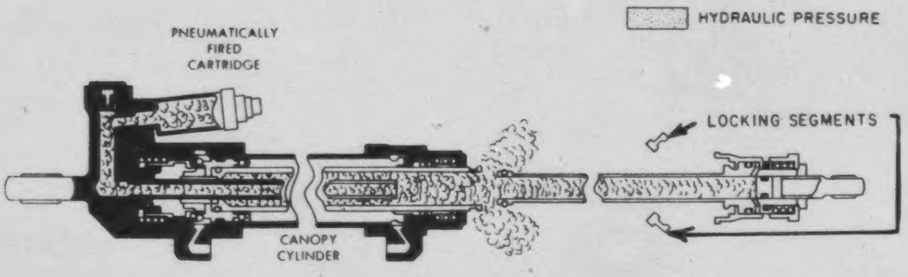
When the canopy opens, hydraulic pressure is ported into the backhead end of the cylinder, causing the piston and rod to extend. As the piston nears the end of its travel in the opposite end of the cylinder, a series of balls, set circumferentially around the piston locking head, contact and depress a telescoping locking plunger against the locking plunger spring. The balls then slide underneath and past a circumferential detent race. After passing the detent, the balls are free to rise, and the locking plunger snaps into place, forcing the balls radially outward behind the detent.

When pressure is applied through the canopy close line, the locking plunger is depressed, under hydraulic pressure, releasing the balls from the detent and freeing the piston. Both ends of the canopy cylinder have identical locking mechanisms.

The pneumatically fired jettison cartridge, located on the back head end of the cylinder, discharges through the jettison feed tube in the core of the piston rod, exerting pressure against the jettison sleeve piston that is telescoped inside the main cylinder piston rod. See fig. 10-29. Locking segments that hold the jettison



PISTON MOVING INTO LOCKED POSITION (MECHANICALLY DEPRESSING LOCKING PLUNGER)



216.219

Figure 10-29.--Canopy actuating cylinder (A-6A).

sleeve in the piston rod will be forced out from underneath their retainer cap, freeing the jettison sleeve to slip out and exit through the rear end of the piston rod. The sleeve, together with the terminal end and the entire canopy, is blown free of the aircraft. The jettison cartridge MUST be removed before performing any maintenance on the canopy hydraulic system.

ANTENNA DRIVE SYSTEMS

Some naval aircraft utilize hydraulic pressure to position one or more of the radar antennas. The A-5 aircraft, for example, utilizes the No. 2 hydraulic system pressure to drive the right- and left-hand side looking radar antennas. Figure 10-30 illustrates the right-hand antenna system of the A-5. Normally, two servo valves and actuators are required for each antenna. They provide antenna sweeping action and allow the antenna to be positioned at the desired azimuth and elevation.

The AMH will generally be concerned with ensuring that these systems receive the designated hydraulic pressure for proper operation. Maintenance of the servo valves and actuators will normally be accomplished by the respective avionics rating responsible for the specific system (AQ/AT). The hydraulic servo valves and actuators are highly precision devices and integrally designed into the systems which they operate. The parts are delicately balanced and can be easily damaged by rough treatment and contamination. Components must be handled with care; avoid dropping or jarring, and take care to prevent a wrench or other tools from striking them.

Maintenance of these servos and actuators, such as seal replacement, requires clean-room considerations afforded by the higher levels of maintenance. The spool valve and small filters within the servo valve can be easily jammed or damaged by dirt. The operation of the valve will most assuredly be affected by contamination introduced through careless handling. Even the tiniest particle can completely or partially block a precision orifice.

AMH personnel assigned to assist the primary work center on joint discrepancies involving maintenance of these systems must be aware that actual maintenance on the servos, actuators, and the filters within such antenna drive assemblies is the responsibility of the avionics rating responsible for the particular system involved and must be accomplished by them under extremely controlled conditions. Organizational level maintenance attempts to perform unauthorized repairs can prove costly in equipment damage or premature system failure and subsequent overhaul.

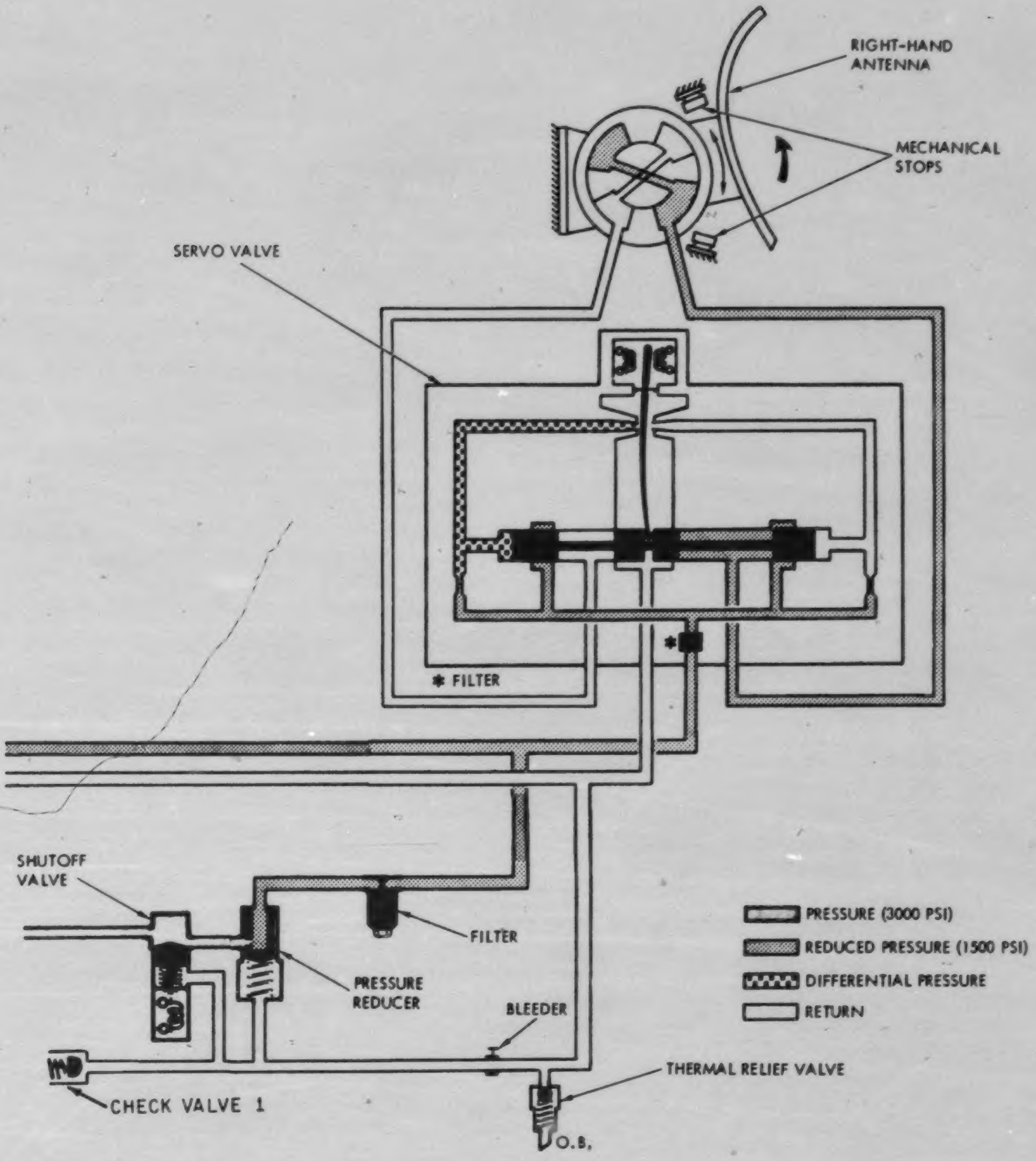
VARIABLE RAMP/ BELLMOUTH SYSTEMS

The airflow velocities encountered in the higher speed ranges of aircraft such as the A-5 and the F-4 are much higher than the engine can efficiently use. Therefore, the air velocity must be controlled for acceptable engine performance.

The variable inlet ramp system positions the inlet ramp (located in the air inlet) so that it will position the shock wave to decrease the inlet air velocity to a subsonic flow with a maximum pressure energy. The system also provides for the deflection and bypass of surplus air not required by the engine with a minimum of drag. The inlet system in combination with the bypass bellmouth system allows the inlet duct to take aboard the maximum free airstream. The air not required by the engine is bypassed by the action of the bellmouth ring.

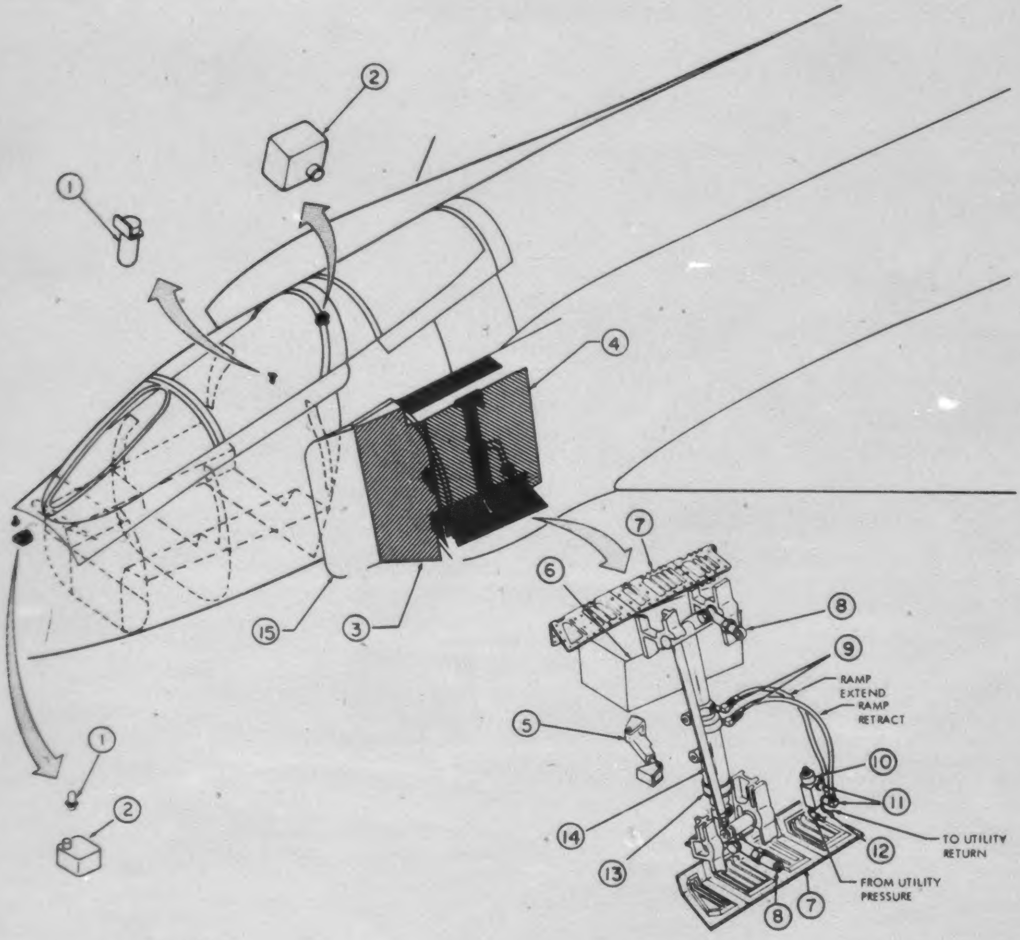
Figure 10-31 illustrates the fixed, perforated, and aft solid ramp sections of the F-4 and its associated hydraulic mechanism and linkage. The aft ramp is positioned by the hydraulic actuator shown in figure 10-32. The actuator is controlled by the electrically operated torque motor in the hydraulic servo valve shown in figure 10-33.

Movement of the aft ramp positions the perforated ramp through mechanical linkage. The position of ramps is automatically selected through the ramp system by a temperature signal from the air data computer set. The ramp actuator is a double-acting cylinder attached to the ramp linkage in such a way as to be free floating. This arrangement causes equal action on the linkages attached to each end of the cylinder.


RIGHT-HAND ANTENNA
MECHANICAL STOPS
SERVO VALVE
*
* FILTER
SHUTOFF VALVE
FILTER
PRESSURE REDUCER
BLEEDER
THERMAL RELIEF VALVE
CHECK VALVE 1
O.B.
PRESSURE (3000 PSI)
REDUCED PRESSURE (1500 PSI)
DIFFERENTIAL PRESSURE
RETURN

216.220

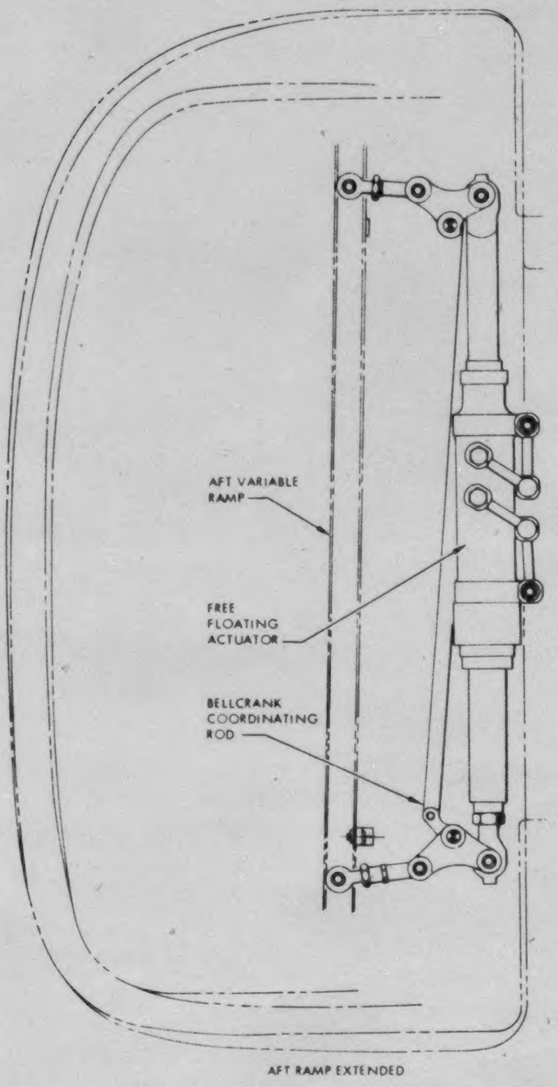
Figure 10-30.—Radar antenna hydraulic servo system.


②
①
④
⑮
③
⑦
⑥
⑧
⑨
RAMP EXTEND
RAMP RETRACT
⑤
⑩
⑪
TO UTILITY RETURN
⑫
⑭
⑬
FROM UTILITY PRESSURE
⑧
⑦
①
②

1. Variable ramp resistor assembly.
2. Variable ramp control amplifier.
3. Perforated forward ramp.
4. Aft solid ramp.
5. Variable ramp feedback potentiometer.
6. Air data computer set (ADCS).
7. Bleed air louver assemblies.
8. Link rod assemblies.
9. Actuator swivel assemblies.
10. Variable ramp servo valve.
11. Servo valve swivel assemblies.
12. Check valve.
13. Variable ramp actuator.
14. Mechanism coordinating rod.
15. Fixed ramp.

216.221

Figure 10-31.—Variable inlet duct ramp system.



216.222

Figure 10-32.—Ramp actuator.

Figure 10-33 illustrates the complete hydraulic portion of the variable ramp system, showing the actuator extending. Actuating the torque motor armature positions the flapper valve in the servo valve, initiating the proper servo action to extend, retract, or hold the actuator in position. As the actuator moves, it positions the ramp through its mechanical linkage.

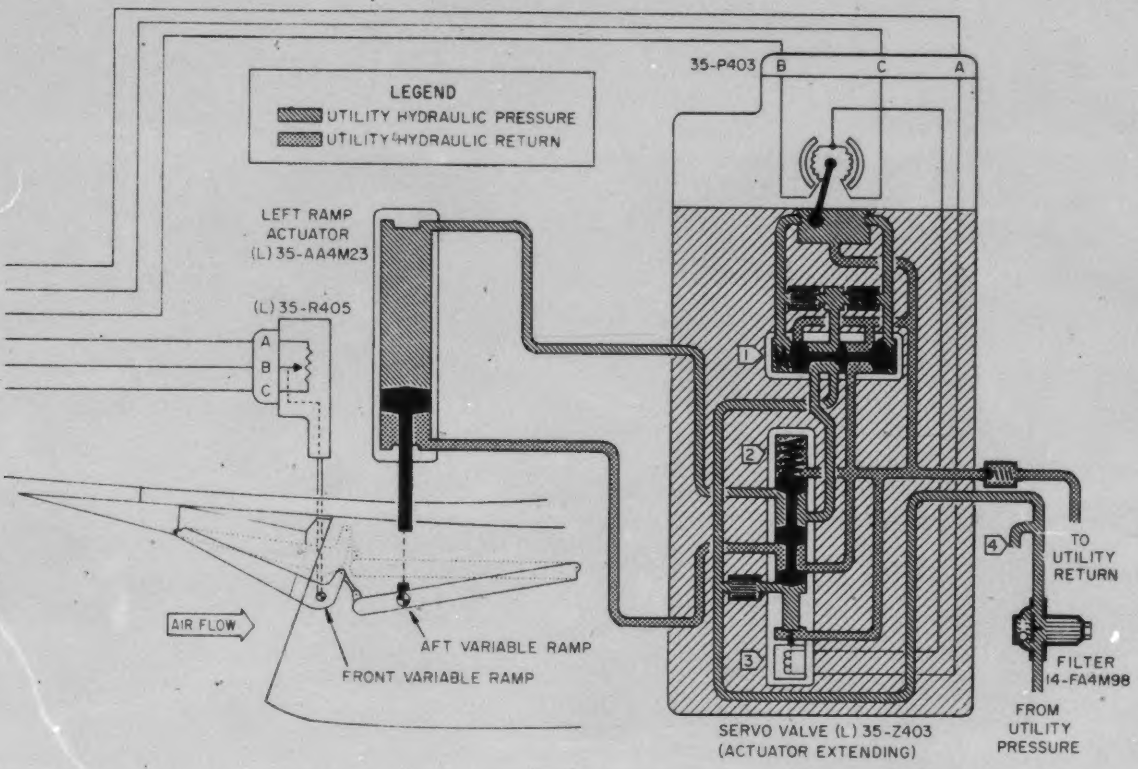
Electrical components in the circuit translate an electrical signal, proportional to the ramp movement, to balance the amplifier circuits and hold the servo and ramp at this designated position until a new temperature signal initiates a change. If electrical or hydraulic power failure occurs, air loads on the ramps will cause the ramps to tend to move toward the retract position.

The variable bypass bellmouth system monitors the inlet duct operation and indicates any corrective action bypassing more or less of the airflow at the engine face as illustrated in figure 10-34.

The system modulates the bypass bellmouth ring position to maintain a preselected inlet airspeed and stable mass airflow through the inlet duct throughout the flight range of aircraft. Movement of the bellmouth ring also controls the amount of secondary air bypassed around the engine for cooling. The valves in the bellmouth controller (fig. 10-34) are positioned by the inlet duct pressure differential and, in turn, direct hydraulic pressure to the bellmouth ring actuator, increasing or decreasing the bypass opening. The holes drilled in the bypass ring assure cooling air to the engine compartment when the ring is in the closed position.

Auxiliary air doors (not shown) open to supplement the bellmouth bypass system at low airspeeds and during ground operation to prevent over temperature and/or reverse airflow in the engine compartment. These doors are located on the underside of the fuselage and open in flight, at high speeds, as required to prevent excessive air pressure differential between the engine compartment and outside ambient.

The auxiliary doors are held closed by hydraulic actuators which are sized to develop a force equivalent to the door area times the designated differential pressure. When the pressure limit is exceeded, the door is pushed open varying amounts to keep the engine


LEGEND
▨ UTILITY HYDRAULIC PRESSURE
▨ UTILITY HYDRAULIC RETURN
LEFT RAMP ACTUATOR (L) 35-AA4M23
(L) 35-R405
A
B
C
35-P403
B
C
A
1
2
3
4
TO UTILITY RETURN
FILTER 14-FA4M98
FROM UTILITY PRESSURE
SERVO VALVE (L) 35-Z403 (ACTUATOR EXTENDING)
AIR FLOW
AFT VARIABLE RAMP
FRONT VARIABLE RAMP

216.223

Figure 10-33.–Ramp servo and actuator.

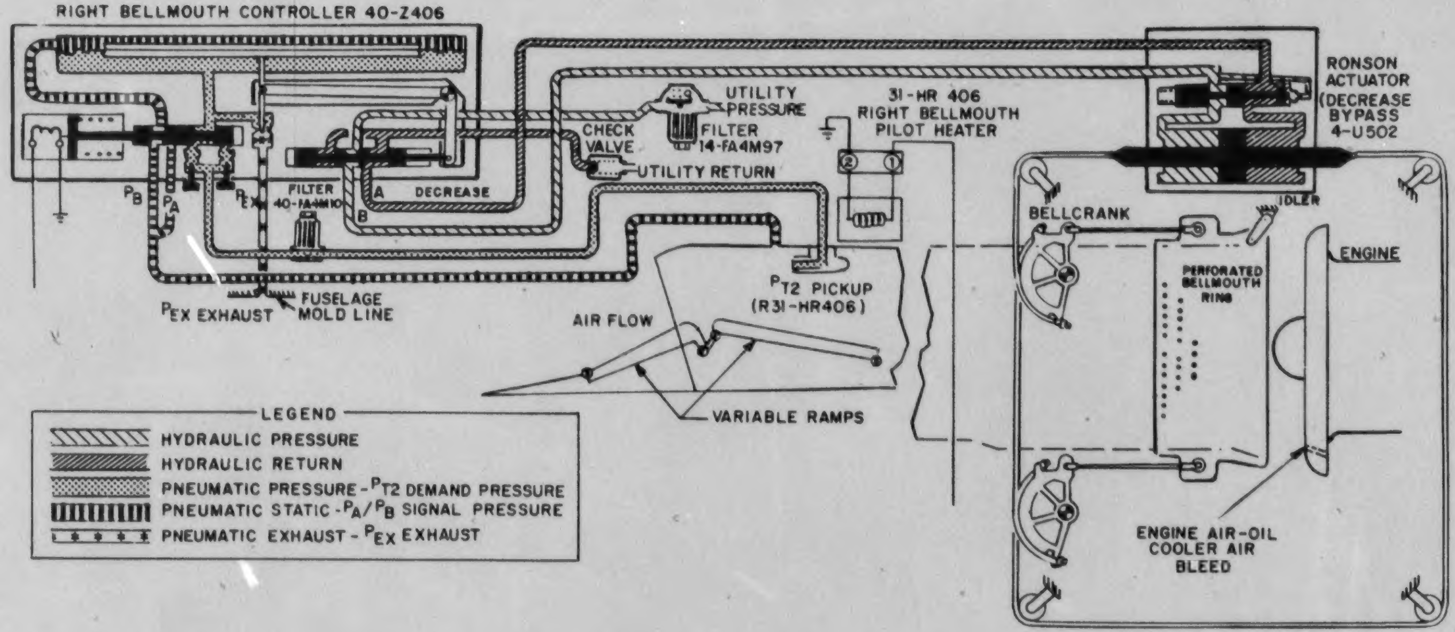
compartment pressure from becoming excessive. As the engine compartment pressure is lowered, the hydraulic actuators will pull the doors closed.

The variable ramp, bellmouth bypass, and auxiliary air door systems are powered by the utility hydraulic system. Malfunctions in these systems will normally require personnel of the AE, ADJ, and AMH ratings working together to operationally test the system and provide proper corrective maintenance.

CORNER REFLECTOR SYSTEM (F-4)

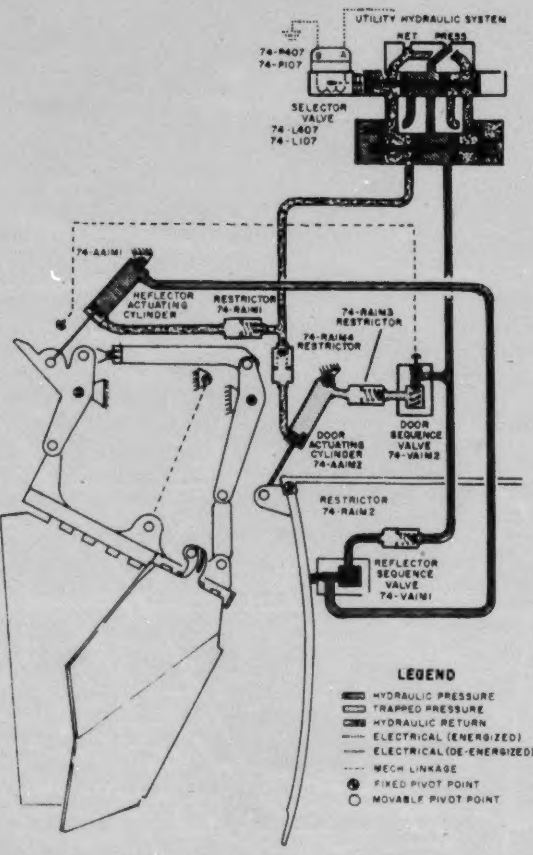
The corner reflector system provides a means of automatically directing the aircraft to a carrier landing. Radar signals sent by the control station are reflected off the corner reflector surface and back to the control station. Information computed from the reflected radar signals is transmitted to the aircraft automatic flight control system for proper navigation to the carrier. The system uses utility hydraulic pressure to extend and retract the reflector, which is located between the radome and nosewheel well door. See fig. 10-35.

Hydraulic components of the system consist of two actuating cylinders, which operate in sequence to actuate the reflector door and extend the corner reflector assembly. The cylinders are controlled by two sequence valves, four one-way restrictors, and a selector valve. The reflector actuating cylinder is connected to components of the reflector assembly by torque tubes, bellcranks, and mechanical linkage. The reflector is made up of four hinged plates which,


RIGHT BELLMOUTH CONTROLLER 40-Z406
RONSON ACTUATOR (DECREASE BYPASS 4-U502
UTILITY PRESSURE
FILTER 14-FA4M97
CHECK VALVE
UTILITY RETURN
31-HR 406 RIGHT BELLMOUTH PILOT HEATER
FILTER 40-FA4M10
A
B
DECREASE
P_B
P_A
P_{EX}
P_{EX} EXHAUST
FUSELAGE MOLD LINE
P_{T2} PICKUP (R31-HR406)
AIR FLOW
VARIABLE RAMPS
BELLCRANK
IDLER
ENGINE
PERFORATED BELLMOUTH RING
ENGINE AIR-OIL COOLER AIR BLEED
LEGEND
HYDRAULIC PRESSURE
HYDRAULIC RETURN
PNEUMATIC PRESSURE - P_{T2} DEMAND PRESSURE
PNEUMATIC STATIC - P_A/P_B SIGNAL PRESSURE
PNEUMATIC EXHAUST - P_{EX} EXHAUST

216.224

Figure 10-34.—Variable bellmouth system (F-4).


UTILITY HYDRAULIC SYSTEM
RET
PRESS
74-P407
74-P107
SELECTOR VALVE
74-L407
74-L107
74-AAIM1
REFLECTOR ACTUATING CYLINDER
RESTRICTOR 74-RAIM1
74-RAIM3 RESTRICTOR
74-RAIM4 RESTRICTOR
DOOR ACTUATING CYLINDER 74-AAIM2
DOOR SEQUENCE VALVE 74-VAIM2
RESTRICTOR 74-RAIM2
REFLECTOR SEQUENCE VALVE 74-VAIM1
LEGEND
HYDRAULIC PRESSURE
TRAPPED PRESSURE
HYDRAULIC RETURN
ELECTRICAL (ENERGIZED)
ELECTRICAL (DE-ENERGIZED)
MECH LINKAGE
FIXED PIVOT POINT
MOVABLE PIVOT POINT

216.225

Figure 10-35.–Corner reflector hydraulic system (F-4).

when retracted, are folded flat into the reflector well. When extended, the reflector forms a pyramid shape with an open base and a small open top.

With electrical and hydraulic power on the aircraft and the landing gear control handle in the DOWN position, the reflector is extended by placing the arresting hook handle to DOWN or the arresting hook bypass switch to BYPASS. The reflector is retracted by raising the hook or returning the bypass switch to NORMAL.

CAUTION: Ensure that personnel are clear during hook operation. The corner reflector retracts and the door will close if electrical power is interrupted while utility hydraulic pressure is applied to the aircraft and the reflector safety strut is not installed. Utility pressure must be depleted prior to attempting to remove the safety strut.

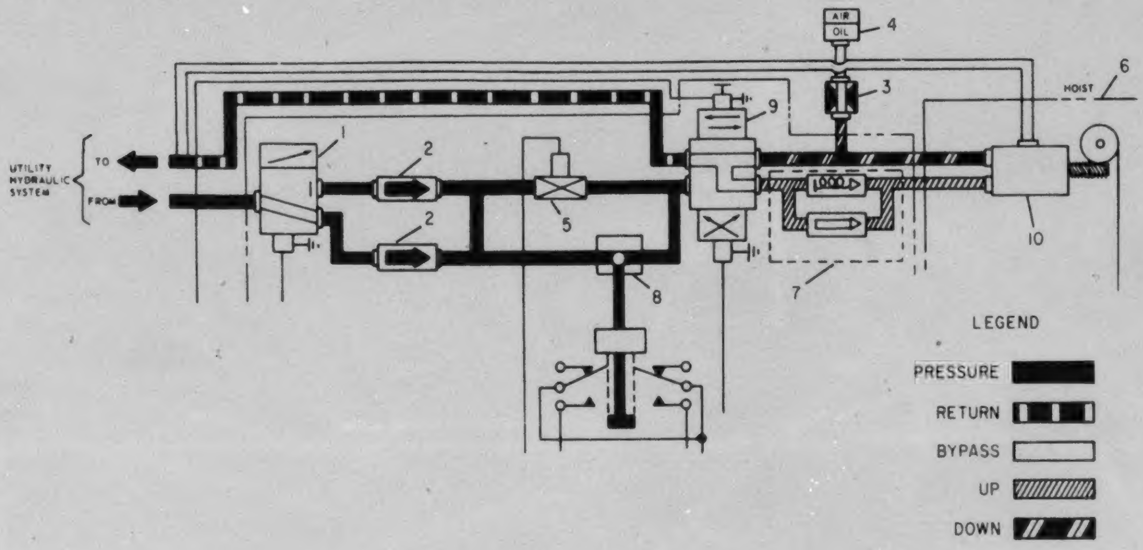
During the opening sequence, pressure from the selector valve is routed through the door sequence valve, through the free flow side of the restrictor and to the reflector door actuating cylinder. When the pressure in the door reaches 500 to 1,000 psi, the cylinder unlocks and opens the door and the reflector sequence valve is opened to allow fluid flow through the free flow side of the restrictor and the sequence valve to the extend side of the reflector actuating cylinder. Pressure in the cylinder extends and holds the reflector in the extended position. During initial reflector movement, the reflector torque tube arm releases the door sequence valve, closing the valve and blocking the extend line of the door actuating cylinder.

The closing sequence reverses the sequence of operation. When the door actuating cylinder reaches the fully closed position, the internal locking mechanism in the cylinder locks the door closed. A torque spring at the universal joint of the fold and unfold mechanism holds tension on the reflector plates to prevent chatter and vibration.

RESCUE HOIST SYSTEM (SH-3A)

The rescue hoist system of the SH-3A, schematically illustrated in figure 10-36, is hydraulically operated. It receives power from the utility system at 3,000 psi and can be controlled from the cockpit or at the hoist control panel by the cargo door. The pilot can control the hoist by placing the hoist switch to PILOT and operating the hoist switch on the pilot's collective pitch stick to UP or DOWN. When operated by the pilot, the speed of the hoist is limited to 50 feet per minute.

To operate the hoist at the hoist control panel, the hoist switch is placed to CREW and the manual speed control handle is rotated either up or down. The operator can vary the



1. Flow control valve.
2. Flow regulators.
3. Restrictors.
4. Accumulator.
5. Shutoff valve.
6. Hoist.
7. Relief valve.
8. Manual speed control valve.
9. Direction control valve.
10. Hydraulic motor.

216.226

Figure 10-36.—Rescue hoist system—schematic diagram (SH-3A) electrical portion deleted.

speed of the hoist from 0 to 200 feet per minute, depending on the degree of handle rotation. Limit switches limit the speed of the hoist to 50 feet per minute when 5 to 7 feet from full retract or extend. Limit switches also stop the hoist when fully extended or retracted.

The flow control valve is a three-way solenoid-operated valve. It is energized whenever the master hoist switch is positioned to PILOT, or whenever it is positioned to CREW, and the hoist slow limit switch is actuated. When energized, it routes hydraulic fluid through the slow flow regulator (50 fpm) and when deenergized, it routes fluid through the high flow regulator (hoist speed 200 fpm).

The accumulator (4) is precharged with 200 psi and maintains constant pressure to ensure that the hoist brake disengages during cable extension.

The shutoff valve (5) is solenoid-controlled and provides a bypass around the manual speed control valve when the hoist is operated by the pilot.

The manual speed control valve is used by the crewmember to vary the speed and select the direction of winch rotation. Positioning the handle up or down progressively increases or decreases the speed of the winch by gradually opening or closing the valve. Microswitches within the valve are closed at three to five degrees rotation of the handle and direct electrical power to actuate the direction control valve.

The direction control valve is solenoid-operated and controls the direction of rotation of the hydraulic motor. Operation of the valve is controlled by the pilot's hoist UP-DN switch, or the microswitches in the crewman's manual speed control valve. The valve can be manually operated in event of electrical failure. During manual operation, limit switches and the cable guillotine circuit are bypassed. Manual operation of this valve should be limited to emergency use.

The hydraulic motor on the hoist drives the cable drum to reel in or pay out the hoist cable. System components throttle fluid flow to the motor inlet or outlet port from 0 to 3,000 psi to control the direction and speed of rotation. On later model hydraulically operated hoists, the hydraulic motor is backed up by an emergency electrical motor system for extending and retracting the cable.

After each mission over salt water, the final 20 feet of cable and all exposed components are washed with fresh water and inspected for evidence of corrosion. After a specified number of lifting cycles or a specified period, the cable is payed out and thoroughly inspected for corrosion, broken strands, fraying, or other damage requiring replacement.

BOMB BAY SYSTEM (P-3)

The bomb bay system of the P-3 is illustrated in figure 10-37. The doors are actuated by mechanical linkage at each end. Each door mechanism is powered by two hydraulic actuating cylinders.

The cylinders for the left door are powered by the No. 1 hydraulic system, and the cylinders for the right door are powered by the No. 2 hydraulic system. The main actuating levers are linked together so that in the event one system fails, the other will be capable of operating both doors. An unlock mechanism is incorporated in the forward linkage to secure the doors when hydraulic power is removed. A hand pump system provides for emergency opening and closing of the doors in event both hydraulic and electrical systems fail. Shutoff valves are provided within each normal system and the emergency hand pump system to isolate the system. Two flow regulators are located upstream of the selector valve (dual system door control valve).

The control valve has three positions–DOORS OPEN, NEUTRAL, and DOORS CLOSED. In the DOORS OPEN position, fluid is ported to the dual controllable check valve, which bypasses pressure to the opening side of the uplock mechanism cylinder. As the cylinder retracts, it unocks the mechanical uplocks and then unseats the dual controllable check valve to port pressure to the open side of the door actuators.

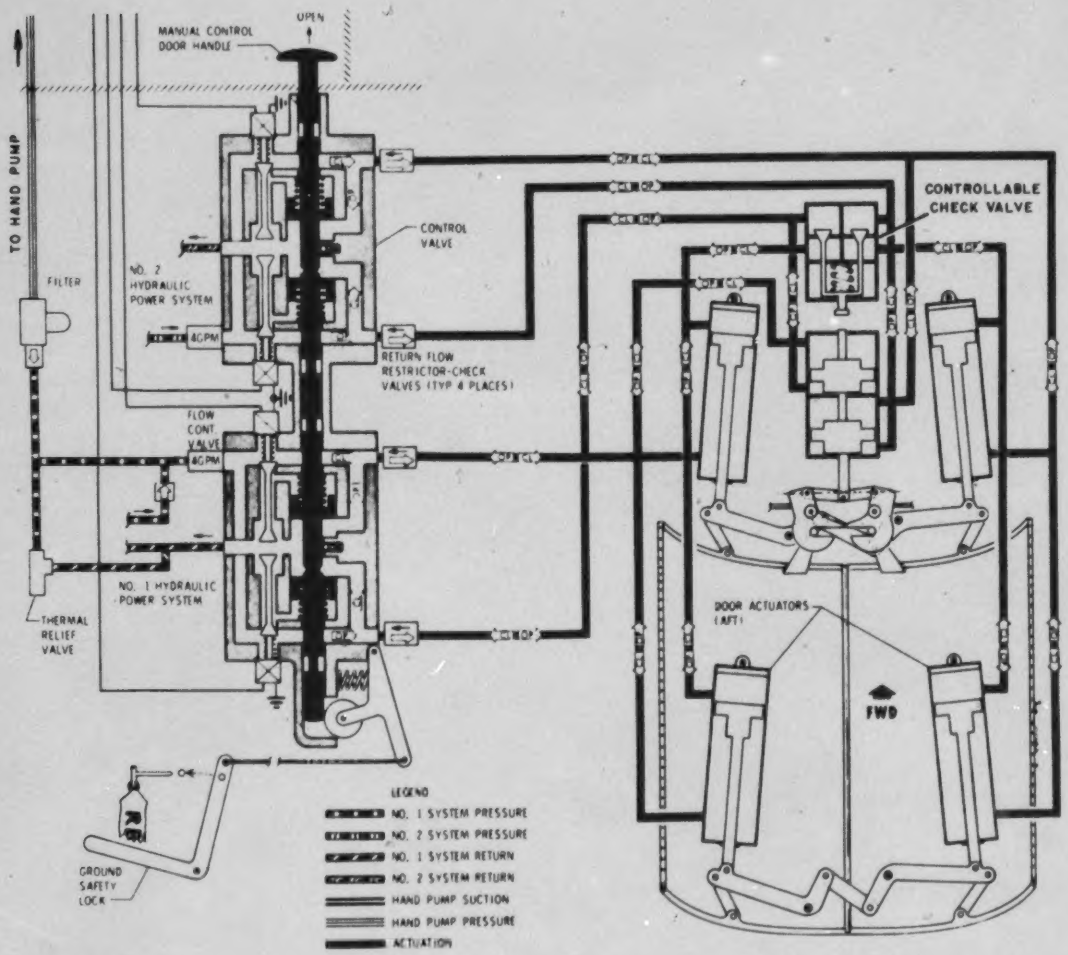
The control valve is normally operated by a two-position switch located on the pilot's armament control panel. The switch energizes either pair of the four solenoids on the control valve to position the main spool to open or close the doors.

The uplock mechanism incorporates an overcenter feature which prevents the assembly from locking until bearings on the doors trip the overcenter mechanism. Limit switches on the uplock mechamism. Limit switches on the uplock mechanism break the electrical circuit to the control valve, and the spring-loaded valve returns to NEUTRAL. In this position, all fluid is ported to the return lines, and the doors are held closed by the mechanical locks. The one-way restrictors installed in the open and close lines ensure smooth door operation and prevent cavitation of the door-actuating cylinders.

Door Control Valve

The door control valve (selector valve) is a dual-system valve with identical operation for each system. It has provisions for manually positioning it in the DOORS CLOSED or OPEN positions. It is spring-loaded to NEUTRAL from the DOORS CLOSED position and detent held in the DOORS OPEN position. In tracing the operation, only one system will be described.

When the doors open solenoids are energized, they seat their respective valves,


TO HAND PUMP
MANUAL CONTROL DOOR HANDLE
OPEN
CONTROL VALVE
FILTER
NO. 2 HYDRAULIC POWER SYSTEM
4GPM
RETURN FLOW RESTRICTOR-CHECK VALVES (TYP 4 PLACES)
FLOW CONT. VALVE
4GPM
NO. 1 HYDRAULIC POWER SYSTEM
THERMAL RELIEF VALVE
GROUND SAFETY LOCK
CONTROLLABLE CHECK VALVE
DOOR ACTUATORS (AFT)
FWD
LEGEND
NO. 1 SYSTEM PRESSURE
NO. 2 SYSTEM PRESSURE
NO. 1 SYSTEM RETURN
NO. 2 SYSTEM RETURN
HAND PUMP SUCTION
HAND PUMP PRESSURE
ACTUATION

216.227

Figure 10-37.—Bomb bay door hydraulic schematic (P-3).

closing the return ports and at the same time unseating the opposite end of the valve to open the pressure port. Pressure is ported to the open side of the main spool positioning piston, moving the spool to the DOORS OPEN position. The opposing doors closed solenoids are deenergized, allowing pressure to seat the pressure port valve and force open the return port valve. The fluid on the close side of the main spool positioning valve is then free to flow into system return.

As the main spool is positioned for DOORS OPEN, it is held in place by an internal detent. When DOORS CLOSED is selected, the pilot valves reverse the flow on the main spool positioning piston, causing it to move off detent and to the DOORS CLOSED position. The main spool reverses the fluid flow to the door cylinders. When the doors are closed and locked, microswitches on the uplock mechanism open a solenoid-operated switch which, in turn, removes electrical current from the doors closed solenoid. This action opens both sides of the spool positioning piston to return and with pressure removed, the spring-loaded main spool assumes its neutral position, causing both sides of the door cylinders to be connected to return. All pressure in the system is relieved and the doors are retained in the locked position mechanically.

When the doors are open, the ground safety lock handle can be placed in the locked position. This mechanically holds the roller mechanism against the end of the control valve main spool and prevents it from being able to move to the DOORS CLOSED position.

Four men are required to safely perform an operational test of the bomb bay system. The safety pin should remain installed during all phases of maintenance, and the system must not be actuated without the expressed all clear signal from the lookout man. The door mechanism interconnecting linkages will cause both doors to operate when either of the doors is cycled. Keep clear of doors and ensure that disconnected linkage is secured in such a manner that it will not cause damage.

CHAPTER 11

GENERAL HYDRAULIC SYSTEM MAINTENANCE

General hydraulic system maintenance discusses those areas that are common to all aircraft hydraulic systems. Utility, flight control, and emergency hydraulic systems utilize tubing and tube fittings to contain the hydraulic fluid or compressed gas within the system. Hydraulic fluid contamination is a universal problem with all hydraulic systems. The proper use and care of hydraulic servicing and testing equipment is as important to the AMH as the maintenance he performs on the aircraft.

TUBING MAINTENANCE

The fabrication and replacement of flareless and flared type rigid tubing assemblies and the various types of flexible hose assemblies are covered in Chapter 10 of the *AMH 3 & 2 Rate Training Manual,* and knowledge of that material is presumed.

Tubing assembly repair is divided into two categories—permanent and temporary. Permanent repairs include removal of minor damage by hand burnishing, line section or fitting replacement using Permaswage equipment, and line section or fitting replacement using induction brazing. Induction brazing is limited to depot level repair.

Temporary repairs are accomplished using splice sections fabricated with flared ends or preset MS sleeves, as most appropriate. Such splice sections are to be replaced with a permanent repair or new tubing assembly at the next rework cycle. Temporary or emergency repairs shall be limited to those cases of tube damage where appropriate equipment, material or circumstance dictate this type repair. Temporary repairs shall not be accomplished at depot level maintenance activities.

Oxygen line tube assemblies requiring repair, other than to minor external surface damage, shall be removed from the aircraft or equipment and replaced by a tube assembly which has been cleaned in accordance with the procedures of *Aviation Hose and Tube Manual* NAVAIR 01-1A-20. If a replacement for the defective assembly is not available, the assembly shall be removed and repaired, and then cleaned in accordance with NAVAIR 01-1A-20 prior to reinstallation. If removal of the defective assembly is not possible and repair in the aircraft is required, refer to applicable Maintenance Instructions Manual (MIM) for appropriate repair and cleaning procedures. Repair of minor damage requiring buffing or burnishing of the exterior surface of the tubing is permitted in the aircraft or equipment.

PERMASWAGE REPAIR PROCEDURE

The Permaswage repair procedure provides the capability and technique for the permanent repair of damaged tube assemblies. Permaswage is designed for use by all levels of maintenance.

The basic element of the repair technique is the Permaswage fitting which is mechanically swaged onto the tube by a hydraulically operated tool. Fittings are available in configurations including permanent unions and shapes (elbows, tees, and crosses), flared, flareless and lip seal separable sleeves and unions, as well as combinations of permanent and threaded fittings. This repair technique is only applicable to tubing assemblies not exceeding the material-line-size-operating pressure requirements of table 11-1. The repair

Table 11-1.–Permaswage repair-tube material and maximum operating pressure limitations (psi)

TUBING MATERIAL	PERMASWAGE FITTING MATERIAL 21-6-9 (MMS-299)									
	3/16"	1/4"	5/16"	3/8"	1/2"	5/8"	3/4"	1"	1 1/4"	1 1/2"
Cres *	(.016)	(.016)	(.016)	(.016)	(.016)	(.016)	(.016)	(.020)	(.024)	(.035)
21-6-9	3000	3000	3000	3000	3000	3000	3000	3000	500	250
AM-350	3000	3000	3000	3000	3000	3000	3000	3000	500	250
304 1/8 H	3000	3000	3000	3000	3000	3000	3000	3000	500	250
304L 1/8 H	3000	3000	3000	3000	3000	3000	3000	3000	500	250
321 1/8 H	3000	3000	3000	3000	3000	3000	3000	3000	500	250
Titanium *	(.016)	(.016)	(.016)	(.019)	(.026)	(.032)	(.039)	(.051)		
3AL-2.5V Cold Red.	3000	3000	3000	3000	3000	3000	3000	3000	500	250
3AL-2.5V Ann.	3000	3000	3000	3000	3000	3000	3000	3000	500	250
6AL-4V Cold Red.	3000	3000	3000	3000	3000	3000	3000	3000	500	250
Al. Al. *	(.020)	(.020)	(.020)	(.020)	(.020)	(.020)	(.020)	(.020)	(.035)	(.035)
6061-T6	3000	3000	3000	3000	3000	3000	3000	1500	250	250

*Minimum Wall Thickness. Maximum Wall Thickness see Table 11-5.

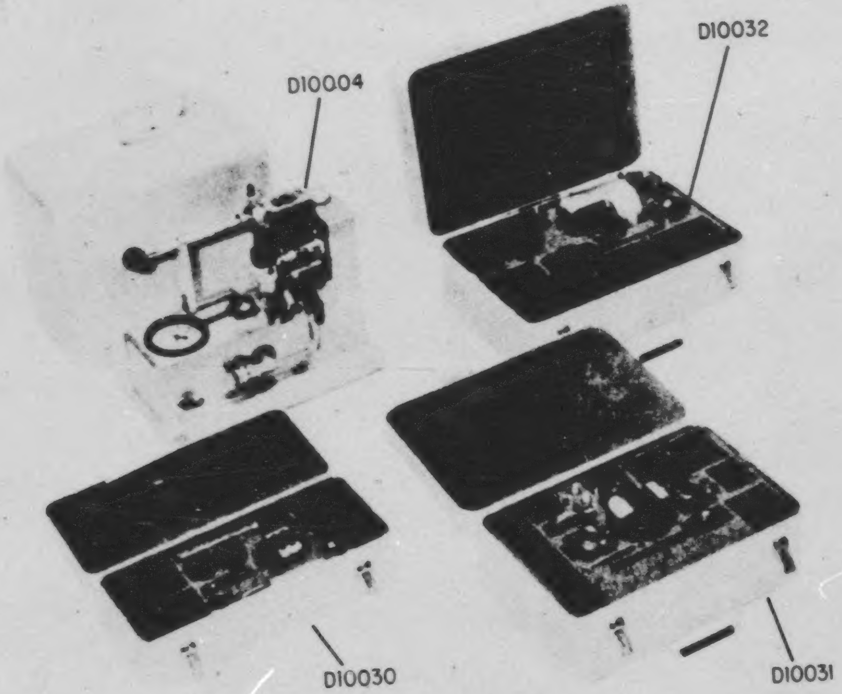


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Figure 11-1.—Permaswage major equipment components.

method is not to be used with annealed corrosion-resistant steel or 5052 aluminum tubing.

CAUTION: Permaswage fittings are manufactured using 21-6-9 corrosion-resistant steel and are compatible only with those tubing materials specified in table 11-1. The use of 21-6-9 Permaswage fittings with tubing material other than that specified in table 11-1 will result in an unacceptable (or unsafe) repair and is prohibited.

Types of Repair

Four basic types of tube assembly failure lend themselves to permanent repair using Permaswage techniques. The failure modes and the recommended repair method for each are described in table 11-2.

Permaswage Technique

The Permaswage technique for tubing repair involves cutting, deburring, tube end preparation, swaging and gaging operations.

Description of Required Equipment

The Permaswage tube repair equipment consists of three separate tool kits and an associated hydraulic pump (figure 11-1). The tool kits differ only in the range of tube sizes that they accommodate, and all operate from the single hydraulic pump provided. Table 11-3 lists the major equipment components by Permaswage part number and indicates the tubing sizes that may be repaired using the three tool kits.

Table 11-2.–Failure modes and recommended repair methods

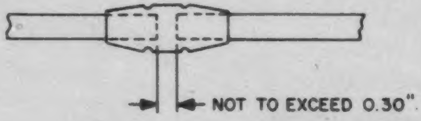
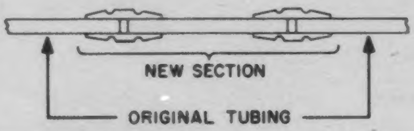
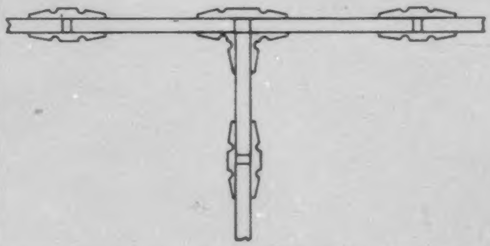
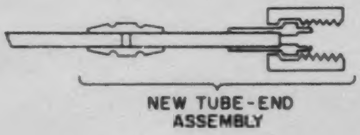
TYPE OF FAILURE	REPAIR METHOD
1. Pin hole leak or circumferential crack in tubing.  	1.a. Make 1 or 2 cuts as necessary, to enable removal of damaged section. If 2 cuts are required, the distance between them shall not exceed 0.30 inch. If this measurement is exceeded, go to repair method 2. b. Swage 1 tube to tube union in tube section under repair.
2. Longitudinal crack in tubing (crack length in excess of 0.30 inch).  	2.a. Make 2 cuts to enable removal of damaged section. b. Remove damaged section and duplicate. c. Swage replacement section into tubing under repair using 2 tube to tube unions.
3. Leaking tee or elbow (permanent tube connection type). 	3.a. Cut out defective tee or elbow. b. Duplicate tubing sections for each branch. c. Swage splice sections to tee or elbow. d. Connect each splice section to tubing under repair using a tube to tube union.
4. Leaking end fitting.  	4.a. Cut tubing to remove defective fitting. b. Make up splice section. c. Swage appropriate end fitting to end of splice section. d. Connect new end fitting to mating equipment connection, torquing nut as required. e. Swage 1 tube to tube union connecting new tube-end assembly to tube section being repaired.

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Table 11-3.—Permaswage major equipment components

MAJOR EQUIPMENT COMPONENTS	FOR USE WITH TUBE SIZES:
Tool Kit #1 Permaswage D10030	3/16" 1/4" 5/16" 3/8"
Tool Kit #2 Permaswage D10031	1/2" 5/8" 3/4"
Tool Kit #3 Permaswage D10032	1" 1 1/4" 1 1/2"
Hydraulic Pump Permaswage D10004	All sizes

Kit Components

Each tool kit contains the tool complement listed in table 11-4.

REPAIR PROCEDURE

Tube Cutting

Three cutting tools are provided to accommodate line sizes from 3/16" through 1 1/2". (See table 11-4 for tool selection per tubing size.)

Before performing the following Permaswage repair procedure, verify that the ratchet is operating freely and the cutter wheel is clear of

Table 11-4.—Tool kit components

KIT COMPONENTS	TOOL KIT PART NUMBER		
	D10030 (Figure 21-2)	D10031 (Figure 21-3)	D10032 (Figure 21-4)
Cutting Tool	D9872	D9853	D9852
Deburring Tool	D9851	D9850	D9849
Hex Key	D9802	D9803	D9803
Marking Tool	D9862S	D9862M	D9862L
Marking Pen	D10058	D10058	D10058
Swaging Tool	D10001	D10002	D10003
Inspection Gage	D9892 (-3-4-5-6)	D9892 (-8-10-12)	D9892 (-16-20-24)

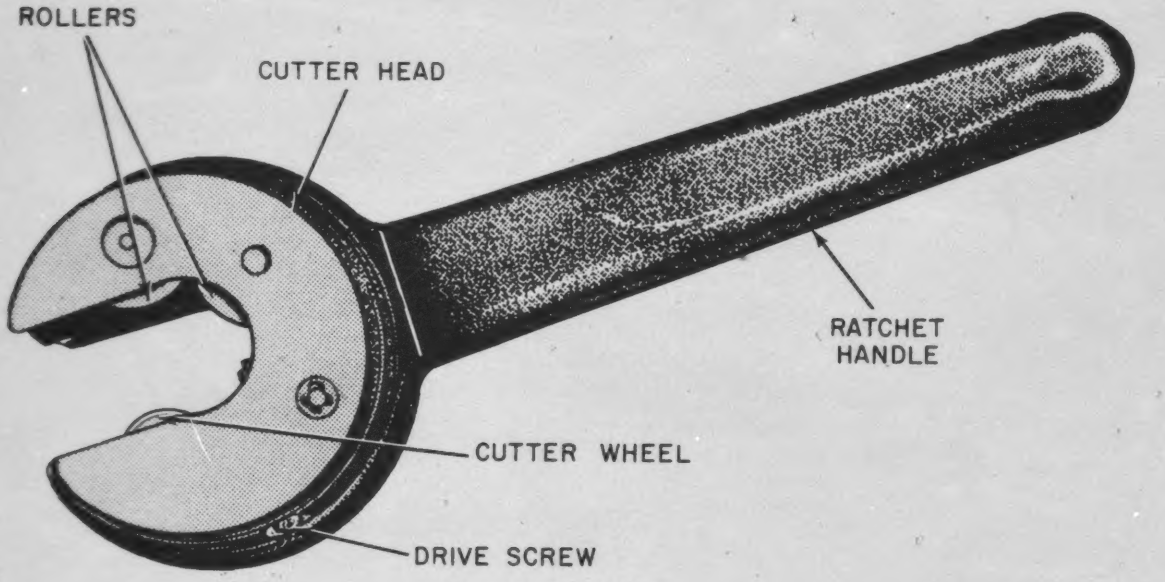

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Figure 11-2.—Chipless cutter.

the cutter head opening. Refer to figure 11-2, then proceed as follows:

1. Rotate cutter head to accept tubing and locate in cutting position. When properly located the tubing will be centered on the two rollers and the cutting blade.

2. Tighten drive screw until light contact is just made by cutter wheel on tube. Then tighten screw an additional 1/8 to 1/4 turn. The screw may be tightened with the hex key provided with kit, a suitable allen wrench, or a screw driver.

CAUTION: Do not over-tighten. In soft tubing a large burr will result. In hard tubing the cutter wheel will experience excessive wear or breakage. Do not put excessive side force on the cutter handle. Side forces will cause cutter wheel breakage.

3. Swing ratchet handle back and forth through the available clearance until there is a noticeable ease of rotation.

4. Tighten drive screw an additional 1/8 to 1/4 turn and continue cutting operation. Readjust drive screw as required to maintain cutter pressure until cut has been completed. Cut shall be within 1/2° square to the tube centerline.

CAUTION: When cutting tubing 1/2" in diameter or larger, after cutter has made one revolution, retighten drive screw 1/8 to 1/4 turn to prevent threading of cutter blade on tubing.

Cutter Lubrication

Lubricate ratchet, rollers, and cutter wheel regularly with general purpose lubricating oil (Federal Specification VV-L-800) to ensure ease of operation.

Cutter Wheel Replacement

When required, the cutter wheel can be replaced.

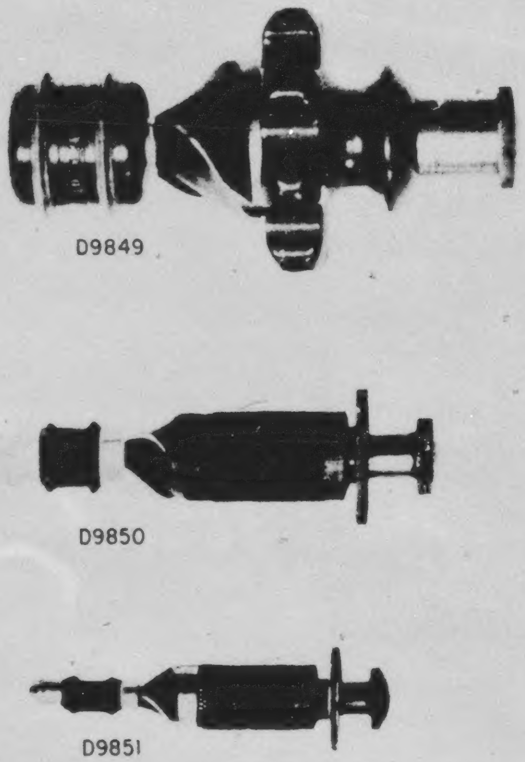

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Figure 11-3.—Deburring tools, with representative stems attached.

Tube Deburring

Special deburring tools are provided to remove burrs from the inside diameter (ID) of the tubing. The tool consists of a plunger-activated stem subassembly, incorporating an elastic plug that is inserted into the tube end up to the point where the cutter makes contact with the burr. Deactivation of the plunger causes the elastic plug of the stem subassembly to expand, thus creating an interference fit with the ID of the tube. Hand rotation of the knurled tool body operates the cutter and accomplishes the deburring, while the elastic plug prevents chips generated during the deburring operation from entering the tubing. After trapping the chips, the plug wipes the tube ID clean as it is withdrawn.

Three sizes of tools are provided that enable deburring of all size tubing from 1/4 inch through 1-1/2 inch outside diameter (OD). Each tool is provided with a set of stem subassemblies to allow precise matching to the tube sizes within its range. Figure 11-3 illustrates the three deburring tools, with representative stem subassemblies installed.

Tool Selection

Refer to table 11-5 and select the deburring tool and stem subassembly required for the size line to be deburred. Proper stem subassembly selection is important, as failure to use the proper size plug will result either in chips entering the tube or difficult plug insertion with resulting plug damage.

Tool Assembly

Assemble the deburring tool as follows:

1. Check sliding collar on end of elastic plug for free movement on stem. Lubricate using light oil, if required.
2. Engage threads and insert stem subassembly into the cutter end of the deburring tool. With the plunger depressed, screw the stem into the plunger until it is bottomed and finger tight.
3. Check assembled tool for proper operation by operating plunger and noting effect on elastic plug. With plunger depressed, the plug OD must be reduced to the same diameter as the metal support collars on either end of the plug. With the plunger released, two distinct circumferential bumps should appear on the surface of plug and project beyond the OD of the metal support collars.
4. Inspect elastic plug for evidence of wear or other damage. A worn or damaged plug could result in chips from the deburring operation entering the tubing.

Tool Operation

Inspect tube end to be deburred for required squareness and proceed as follows:

1. Ensure that the outer surface of elastic plug is clean and free of chips or other dirt.

Table 11-5.—Stem subassembly selection chart

D9851 DEBURRING TOOL

Tube OD	Tube Wall Thickness	Stem Subassembly Required
1/4"	.016–.028"	D9851-13-04
	.028–.050"	D9851-13-03*
5/16"	.016–.035"	D9851-13-05
3/8"	.016–.035"	D9851-13-06
	.035–.058"	D9851-13-07

D9850 DEBURRING TOOL

Tube OD	Wall Thickness	Stem Subassembly Required
1/2"	.016–.042"	D9850-13-08
	.042–.065"	D9850-13-09
5/8"	.016–.058"	D9850-13-10
3/4"	.016–.065"	D9860-13-12

D9849 DEBURRING TOOL

Tube OD	Wall Thickness	Stem Subassembly Required
1"	.020–.083"	D9849-13-16
1 1/4"	.024–.065"	D9849-13-20
1 1/4"	.065–.109"	D9849-13-21
1 1/2"	.028–.083"	D9849-13-24

*May be used to deburr 3/16" tubing.

Clean, if required, and lightly lubricate using a lubricant compatible with the fluid to be used in the tubing.

2. Grasp the tool in one hand with two fingers on the collar and thumb on the plunger. Depress plunger with thumb and insert the elastic plug into the tube opening until the cutter is approximately 1/8" from the tube end.

NOTE: If the plug fit is tight due to a large burr on ID of the tube, slowly rotate the plunger end of the tool while gently pushing into the tube end. When tool is properly positioned, release plunger thus allowing elastic plug to expand and establish the required seal.

3. Holding the tube end with one hand, rotate the knurled body of the deburring tool in a clockwise direction while applying slight pressure to the cutter. Continue to rotate until the cutter rotates smoothly, indicating the removal of all burrs from the tube ID. Relax pressure and rotate cutter several more times to produce a smooth surface on the resulting chamfer.

4. Without depressing the plunger, ease the tool from the tube until the first bulge of the plug is exposed. Wipe off the tube end and plug and inspect tube end to determine if it has been properly deburred.

5. If tube end appears satisfactory, pull the tool completely out of the tube, taking care not to operate the plunger. If the tube end has not been completely deburred, push tool back into the tube, again being careful not to operate the plunger, and repeat steps 3, 4, and 5.

6. Inspect tube end and tube ID for loose chips or other debris. Wipe down, if required, using clean wiping cloths.

7. Thoroughly wipe deburring tool to remove all traces of chips and dirt, particularly from the elastic plug.

Tube End Preparation

The tube end to be swaged shall be deburred and square to within 1/2° of square to the tube centerline. Deburring forms a slight chamfer on the inner edges of the cut tube. The chamfer shall be a maximum of 1/2 of the tube wall thickness at an angle no greater than 45°. Mark the tube ends with a tube insertion band or mark using the felt tip pen (provided with kit), ink, or other suitable marking media in

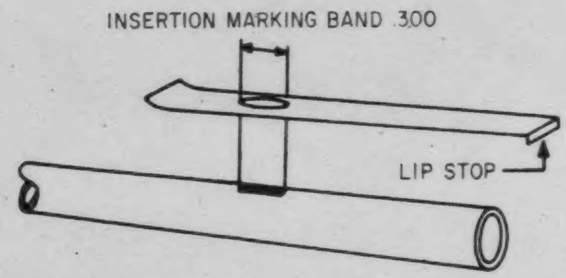

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Figure 11-4.—Marking with permaswage marking tool.

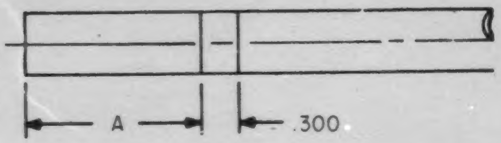

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Figure 11-5.—Tube end marking.

accordance with one of the following procedures:

a. Tube Insertion Mark using Permaswage Marking Tool D9862 may be accomplished by positioning the lip stop of the marking tool, as indicated in figure 11-4, over the end of the tube to be swaged. Use the appropriate tube size slot as a marking guide making sure the total width of the mark is made on the tube. The tube insertion length and .300 of an inch marking band width are part of the D9862 marking tool.

b. Using table 11-6 determine the Tube Insertion Band Location as shown in figure 11-5. (This method is used when permaswage Marking Tool is not available.)

Table 11-6.—Tube insertion band location

TUBE DIAMETER (INCHES)	DASH SIZE	"A" DIMENSION +.010 -.000 INCHES
3/16	(-3)	1.475
1/4	(-4)	1.475
5/16	(-5)	1.475
3/8	(-6)	1.475
1/2	(-8)	1.995
5/8	(-10)	2.065
3/4	(-12)	2.065
1	(-16)	2.240
1- 1/4	(-20)	2.240
1- 1/2	(-24)	2.240

SWAGING OPERATION

General Description

Swaging tools D10001, D10002, and D10003 are used to make permanent tubing joints by swaging an appropriate permaswage fitting onto compatible tubing. The types of tubing are restricted to those aluminum, stainless steel, or titanium tubings listed in table 11-1. The fittings may be unions, tees, crosses, separable fittings, reducer fittings, and other special fittings. A tube end gap installation tolerance of .300 inch is provided to facilitate production assembly for all fittings except separables which have .150 inch gap. Each of the three swaging tools covers a range of tubing sizes as shown in the following list:

SWAGING TOOL	TUBING SIZE
D10001	3/16" (-3) 1/4" (-4) 5/16" (-5) 3/8" (-6)
D10002	1/2" (-8) 5/8" (-10) 3/4" (-12)
D10003	1" (-16) 1-1/4" (-20) 1-1/2" (-24)

Operation of Swaging Tool

In operation, hydraulic pressure supplied by the portable hydraulic power supply is converted into mechanical movement. The mechanical movement is of sufficient force to cause die segments, contained within the swaging tool, to perform the swaging function. The swaging tool is designed to operate over a range of tubing sizes and types of fittings by changing die block assemblies and/or fitting locators. The die block assemblies are supplied in sets consisting of upper and lower die blocks, dies and locators. The lower die block is retained on the basic swage tool assembly to assure automatic retraction and consistent repeatability. The upper die block assembly is removable for easy loading.

Swaging Tool Operating Instructions

To operate the swaging tool, proceed as follows:

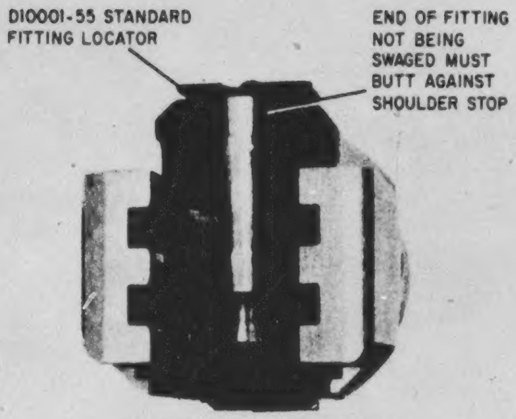
1. Connect hydraulic pressure line from hydraulic power supply to fitting on base swaging tool.
2. Set selector valve on hydraulic power supply to EXHAUST. (This relieves all pressure in line and ensures sufficient room for the upper die block to be inserted over the lower die block.)
3. To ensure against undesirable air entrapment in hose and swaging tool, install a set of die blocks in the tool and position the tool below the level of the hydraulic power supply. Then cycle the hydraulic power supply to 2000 psi followed by EXHAUST. Two or three cycles may be required.
4. Select the correct upper and lower die block assemblies for size of fitting to be swaged. If either die block is too small, upper die block will not load. If either is too large, fitting will swage improperly.
5. Insert the lower die block (with correct fitting locator option dependent on type of fitting) into the swaging tool. When properly inserted the fitting locator is on opposite end of tool relative to latch.
6. Place the swaging tool on fitting to be swaged with fitting over the lower die block and positioned so that end not being swaged is butted up against shoulder stop of fitting locator in figure 11-6. (Refer to figure 11-7 for positioning of shaped fittings.)
7. Insert the upper die block assembly into swaging tool from the latch side of tool. On D10001 only, the upper die block assembly may also be inserted from top of the tool head.
8. Push the latch up to lock the upper die block assembly into position over the lower die block assembly.
9. Position the face of the swaging tool against the location mark on tube. The outer edge of the latch must fall within location mark. (See figure 11-8.)

CAUTION: Insufficient or too much tube insertion in the Permaswage fitting is cause for rejection of the joint.

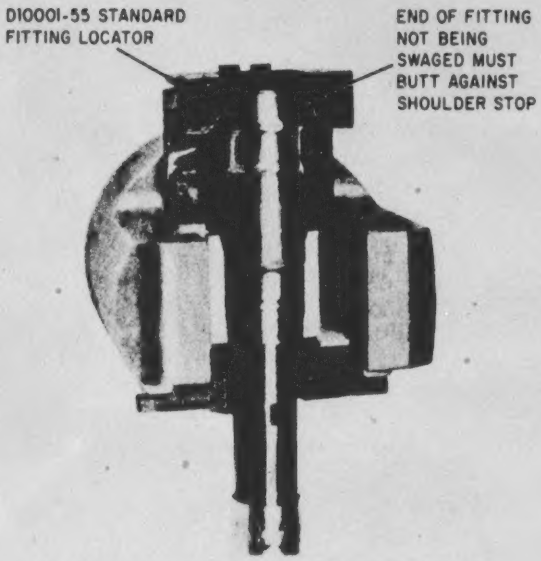
10. Set the selector valve to the appropriate hydraulic output.
11. Actuate the swaging tool with 5,500±250-psi hydraulic pressure in line from the hydraulic power supply. This may be accomplished manually by pumping the handpump on the hydraulic power supply until the gage indicates 5500 psi, or automatically by using the shop-air connection and pressing the local or remote air switch until the gage indicates 5500 psi. Under-pressurization will result in an improperly swaged joint. Over-pressurization will put undue stresses on the swaging tool, the fitting, and the tube.
12. Set the selector valve to EXHAUST to relieve pressure completely.
13. Slide the latch to the OPEN position.
14. Remove the upper die block assembly by sliding out from the end of the swaging tool, or up through the slots in the tool head on D10001.

NOTE: If the upper die block assembly is difficult to remove, check to see that pressure has been completely relieved.

15. Remove the swaging tool from the swaged joint.
16. Inspect the swaged end with appropriate size D9892 "go/no go" inspection gage.
17. If the inspection gage does not fit as required, reswage the fitting by repeating steps 5 through 15 above.


D10001-55 STANDARD FITTING LOCATOR
END OF FITTING NOT BEING SWAGED MUST BUTT AGAINST SHOULDER STOP

(A) STANDARD UNION IN D10001


D10001-55 STANDARD FITTING LOCATOR
END OF FITTING NOT BEING SWAGED MUST BUTT AGAINST SHOULDER STOP

(B) STANDARD UNION IN D10002 OR D10003

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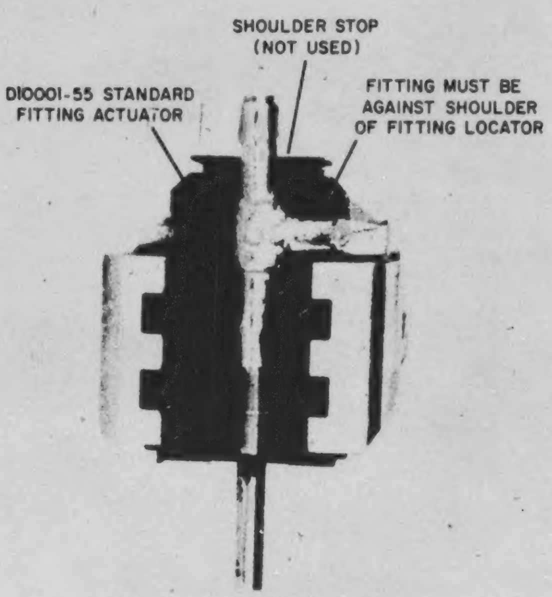
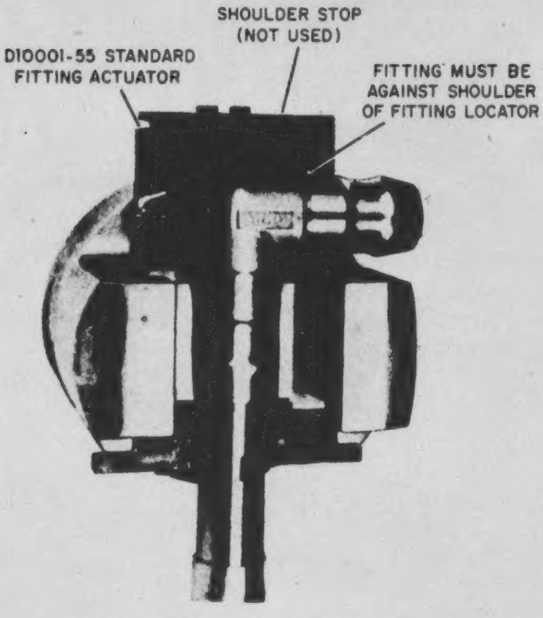
Figure 11-6.—Standard union fitting in swaging tool with standard fitting locator.


SHOULDER STOP (NOT USED)
D10001-55 STANDARD FITTING ACTUATOR
FITTING MUST BE AGAINST SHOULDER OF FITTING LOCATOR

(A) SHAPED FITTING IN D-10001


SHOULDER STOP (NOT USED)
D10001-55 STANDARD FITTING ACTUATOR
FITTING MUST BE AGAINST SHOULDER OF FITTING LOCATOR

(B) SHAPED FITTING IN D10002 OR D10003

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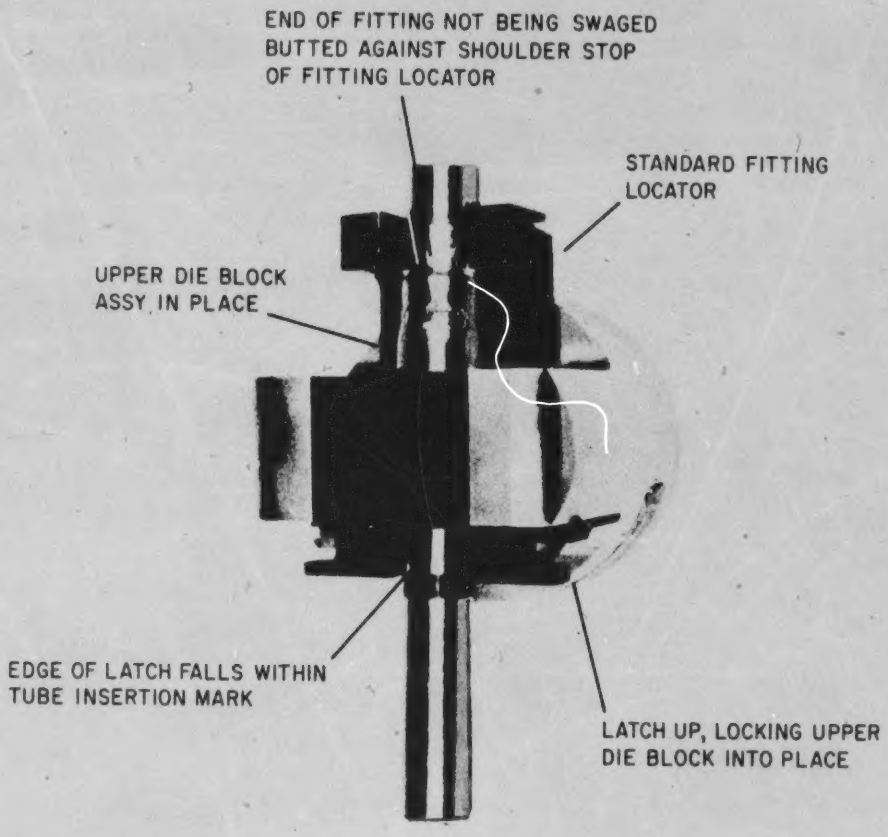
Figure 11-7.—Shaped fitting in swaging tool with standard fitting locator.


END OF FITTING NOT BEING SWAGED BUTTED AGAINST SHOULDER STOP OF FITTING LOCATOR
STANDARD FITTING LOCATOR
UPPER DIE BLOCK ASSY IN PLACE
EDGE OF LATCH FALLS WITHIN TUBE INSERTION MARK
LATCH UP, LOCKING UPPER DIE BLOCK INTO PLACE

216.257

Figure 11-8.—Ready for swaging.

Inspection/Checking

Inspection/checking of swaged joints is accomplished visually and with the aid of the D9892 Inspection Gage of correct dash (-) size for the swaged fitting. See table 11-6. Proper use of the correct inspection gage ensures:

1. Length of tube-to-fitting engagement.
2. Outside diameter of the swaged fitting.
3. Length of the swaged portion of the fitting.

Inspection/Checking Instructions with Inspection Gage.

Proceed as follows:

a. Visually inspect for cracks in the fitting or the tube.

b. Place the D9892 Inspection Gage of correct size on swaged fitting shown in figure 11-9.

NOTE: The use of die segments produces longitudinal ridges ("flash" marks) on the swaged fitting.

c. Rotate the gage between "flash" marks. Gage must fit over all swaged segments between "flash" marks.

d. If fitting does not meet requirements of inspection gage, corrective action shall be taken as indicated in table 11-7, Troubleshooting guide for inspection/checking.

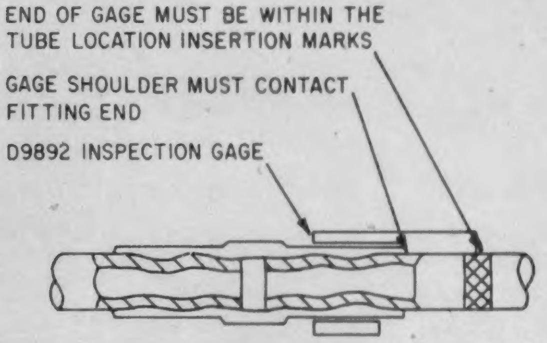

END OF GAGE MUST BE WITHIN THE TUBE LOCATION INSERTION MARKS
GAGE SHOULDER MUST CONTACT FITTING END
D9892 INSPECTION GAGE

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Figure 11-9.—Checking swaged joint with D9892 inspection gage.

Inspection/Checking Instructions Without Inspection Gage.

Proceed as follows:

a. Visually inspect for cracks in the fitting or the tube.

b. In the absence of the proper inspection gage, the swaged fitting shall meet the dimensional requirements of table 11-8 and figure 11-10.

NOTE: The outside diameter ("A" Dimension in table 11-8) must be measured in the area between the longitudinal ridges ("flash" marks) produced by the swaging action of the die segments.

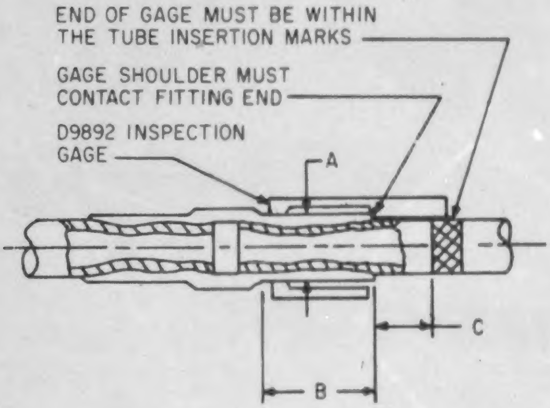
PERMASWAGE TUBE/FITTING INSTALLATION TOLERANCES

These tolerances apply to tube end gap limits and acceptable or nonacceptable limits of the standard Permaswage union fitting.

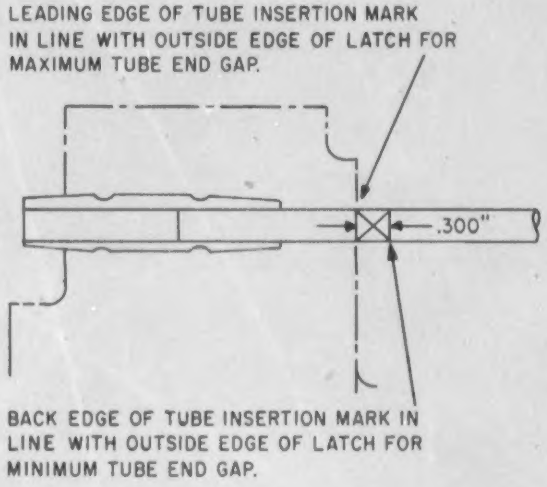
The following instructions apply to union fittings (see figure 11-11); shaped fittings (elbows, tees, crosses, and shaped reducers as in figure 11-12); and separable fittings (MS and AN, male and female as in figure 11-13.

1. For MAXIMUM tube end gap, the leading edge of the tube insertion mark must be in line with the outside edge of the swaging tool latch.

2. For MINIMUM tube end gap when using union and shaped fittings, the back edge of the tube insertion mark must be in line with the outside edge of the latch.


END OF GAGE MUST BE WITHIN THE TUBE INSERTION MARKS
GAGE SHOULDER MUST CONTACT FITTING END
D9892 INSPECTION GAGE
A
C
B

216.259
Figure 11-10.—After swaging dimensions (Use with Table 11-8).


LEADING EDGE OF TUBE INSERTION MARK IN LINE WITH OUTSIDE EDGE OF LATCH FOR MAXIMUM TUBE END GAP.
.300"
BACK EDGE OF TUBE INSERTION MARK IN LINE WITH OUTSIDE EDGE OF LATCH FOR MINIMUM TUBE END GAP.

216.260
Figure 11-11.—Utilizing .300" tube end gap tolerance with standard union fittings.

Table 11-7.—Troubleshooting guide for inspection checking

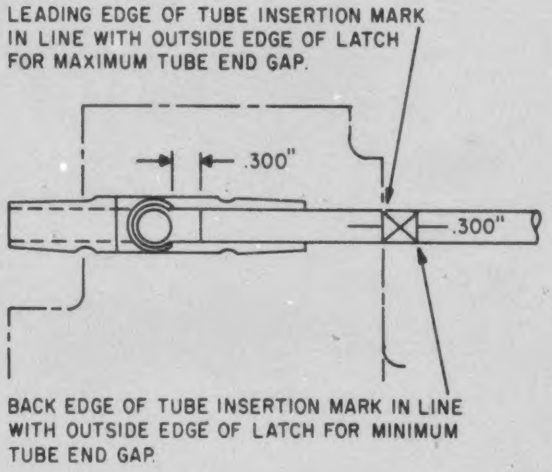
INDICATION	POSSIBLE PROBLEM	CORRECTIVE ACTION
Fitting does not swage at all.	Swaging with less than 5,500±250 psi to tool.	Check hydraulic power supply and fittings to tool.
	Improper size die blocks (too large).	Install proper die block assemblies.
Gage will not fit over swaged fitting outside diameter.	Swaging with less than 5,500 psi.	Reswage.
	Attempting to read over flash marks.	Rotate gage off flash marks.
	Die segments and walls of die blocks must be clean.	Carefully remove die segments from die blocks and: 1) Clean between die sectors. 2) Clean and lubricate die block side surfaces and those surfaces in contact with die segments with a light film of TFE spray lubricant.
Gage shoulder does not contact end of fitting.	End of fitting must be in contact with fitting locator shoulder stops on swaging tool.	Reswage. Locator shoulder stops may be damaged; if so, they should be replaced.
Gage finger does not fall within tube insertion mark on tubing.	Tube insertion mark did not coincide with face of tool (outside edge of safety latch) during swaging of both ends.	Cut out the fitting.

Table 11-8.—Fitting dimensions after swaging

TUBE DIAMETER		MAXIMUM SWAGED DIA. "A" DIMENSION	MINIMUM SWAGED LENGTH "B" DIMENSION	TUBE LOCATION "C" DIMENSION
(Inches)	(Size)	(Inches)	(Inches)	(Inches)
3/16	(-3)	0.2465	0.340	1.010 to 0.710
1/4	(-4)	0.315	0.460	0.865 to 0.565
5/16	(-5)	0.3815	0.500	0.820 to 0.520
3/8	(-6)	0.447	0.530	0.784 to 0.484
1/2	(-8)	0.606	1.020	0.820 to 0.520
5/8	(-10)	0.735	1.020	0.820 to 0.520
3/4	(-12)	0.853	1.020	0.820 to 0.520
1	(-16)	1.144	1.160	0.820 to 0.520
1-1/4	(-20)	1.30	1.160	0.820 to 0.520
1-1/2	(-24)	1.597	1.160	0.820 to 0.520

NOTE

It is permissible and advisable to reswage fittings in order to comply with dimensions in table 11-8, providing that the correct upper and lower die block assemblies are employed.

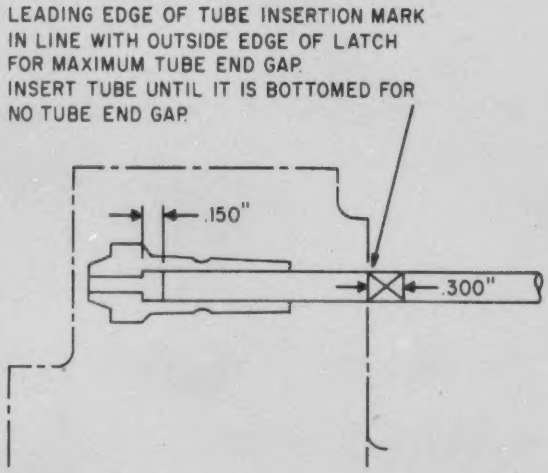


LEADING EDGE OF TUBE INSERTION MARK IN LINE WITH OUTSIDE EDGE OF LATCH FOR MAXIMUM TUBE END GAP.

BACK EDGE OF TUBE INSERTION MARK IN LINE WITH OUTSIDE EDGE OF LATCH FOR MINIMUM TUBE END GAP.

216.261

Figure 11-12.–Utilizing .300" tube end gap tolerance on shaped fittings.



LEADING EDGE OF TUBE INSERTION MARK IN LINE WITH OUTSIDE EDGE OF LATCH FOR MAXIMUM TUBE END GAP.
INSERT TUBE UNTIL IT IS BOTTOMED FOR NO TUBE END GAP.

216.262

Figure 11-13.–Utilizing .150" tube end gap tolerance on separable fittings.

3. For MINIMUM tube end gap using separable fittings only, the tube is inserted until it is bottomed.

Acceptable tube insertion limits when using unions are shown in figure 11-14(A). Nonacceptable limits are shown in figure 11-14(B).

HYDRAULIC POWER SUPPLY (D10004)

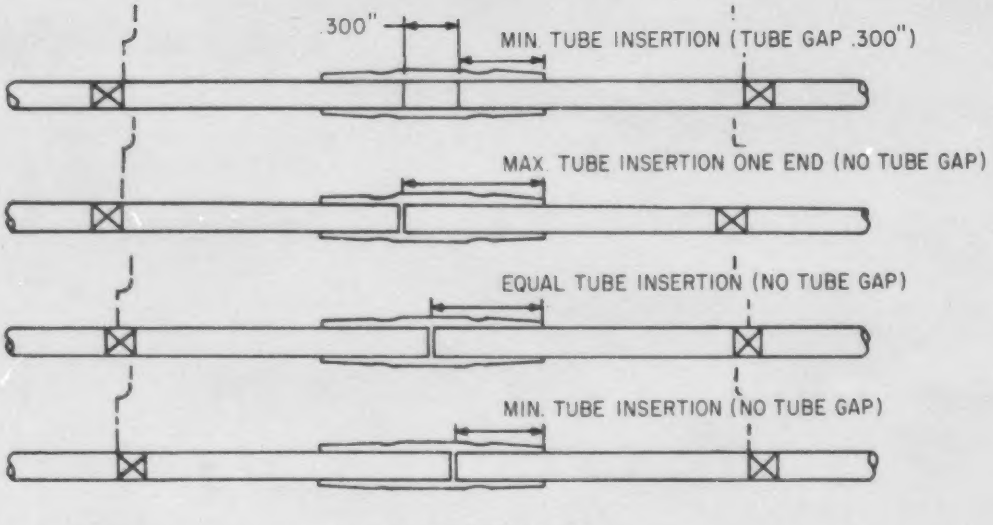
The portable hydraulic power supply (figure 11-15) generates the pressure required to operate the swaging tool. MIL-H-5606 fluid is fed to the tool through a 1/4-inch quick-disconnect high-pressure hose. A swaging pressure of 5,500 psi, applied to all tubing sizes and materials, may be attained by either manual operation of the hand pump or air-to-hydraulic fluid intensification from a 60- to 100-psi shop air source. A remote control air switch is provided for activation of the air-to-hydraulic fluid intensifier. As a precaution against premature tool fatique, the swaging pressure level is kept from exceeding 5,500 psi by a pressure relief valve. Upon completion of swaging, pressure is reduced to zero by operation of a manual 4-way selector valve.

Manual Operation

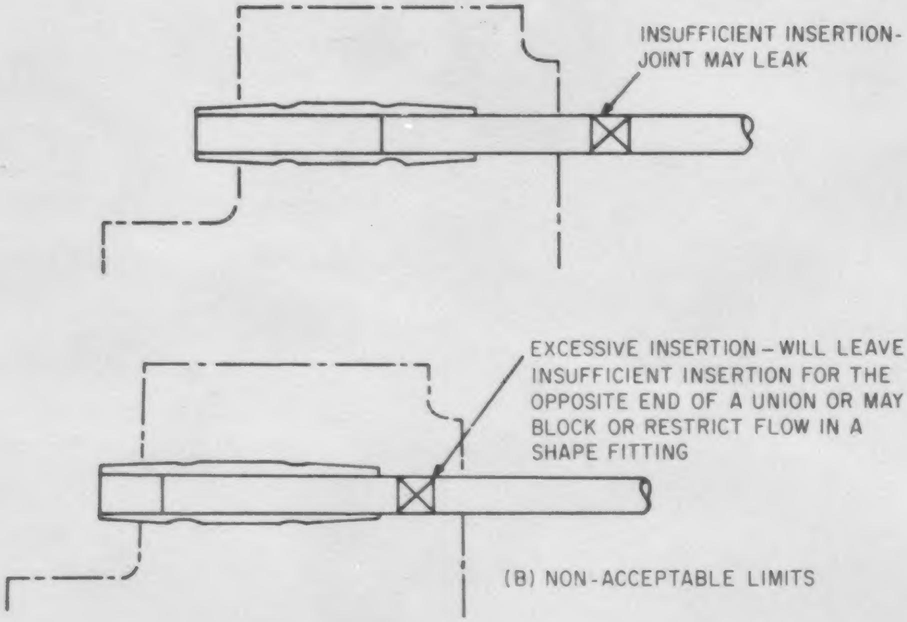
Swaging pressure is attained by hand operation of the pump. Refer to figure 11-15 during the following procedure:

1. Verify that reservoir is full by checking level of sight gage. Use only hydraulic fluid conforming to MIL-H-5606.
2. Prepare swaging tool for operation.
3. Connect hose and swaging tool to either hydraulic output.
4. Set selector valve to appropriate hydraulic output.
5. When swage is desired, operate pump handle until output pressure gage reads 5,500 psi.

NOTE: Hydraulic pressure relief valve should be set for automatic relief at 5,500±250


.300"
MIN. TUBE INSERTION (TUBE GAP .300")
MAX. TUBE INSERTION ONE END (NO TUBE GAP)
EQUAL TUBE INSERTION (NO TUBE GAP)
MIN. TUBE INSERTION (NO TUBE GAP)

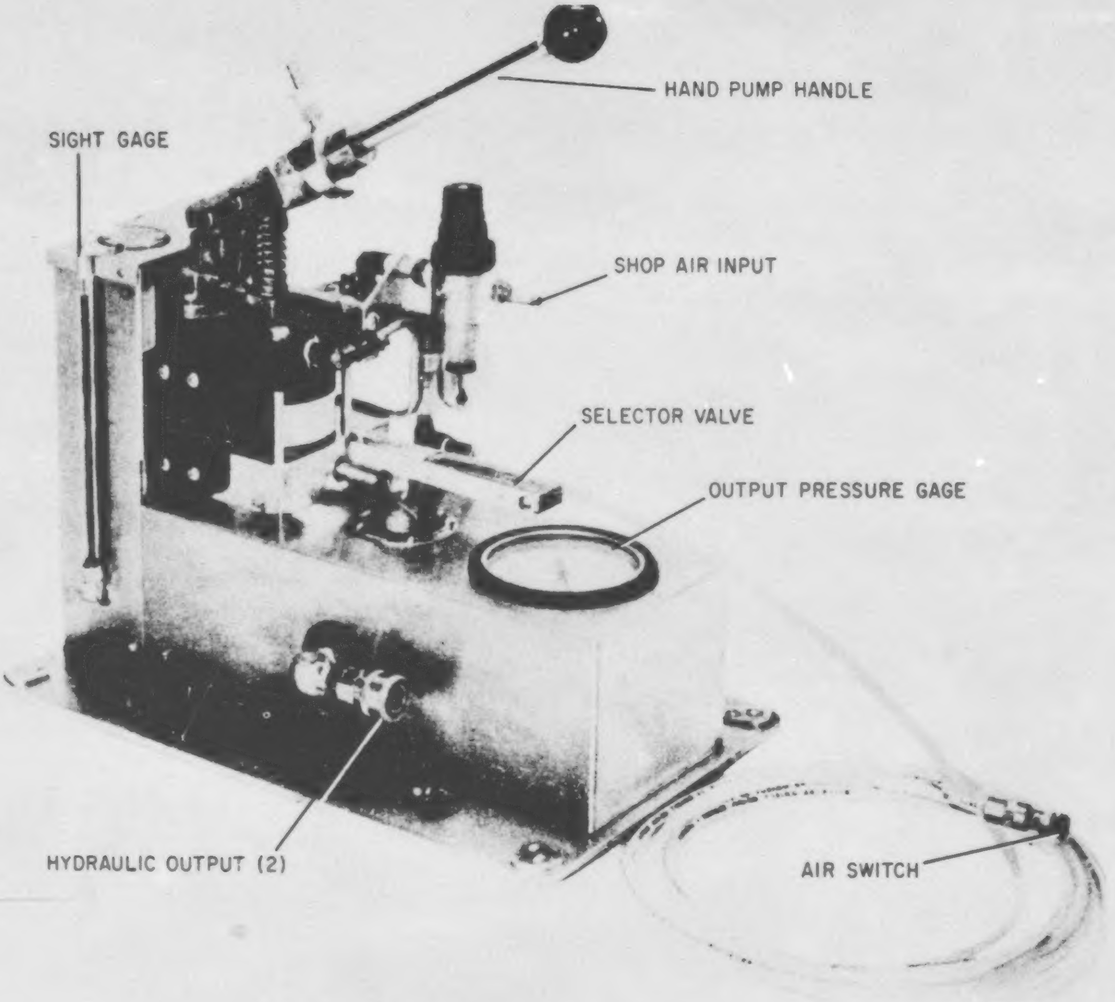
(A) ACCEPTABLE LIMITS


INSUFFICIENT INSERTION-
JOINT MAY LEAK
EXCESSIVE INSERTION - WILL LEAVE
INSUFFICIENT INSERTION FOR THE
OPPOSITE END OF A UNION OR MAY
BLOCK OR RESTRICT FLOW IN A
SHAPE FITTING

(B) NON-ACCEPTABLE LIMITS

216.263

Figure 11-14.—Tube insertion limits when using standard union fittings.


HAND PUMP HANDLE
SIGHT GAGE
SHOP AIR INPUT
SELECTOR VALVE
OUTPUT PRESSURE GAGE
HYDRAULIC OUTPUT (2)
AIR SWITCH

216.264

Figure 11-15.—Hydraulic power supply.

psi. If variance is noticed, follow calibration procedures listed in NAVAIR 01-1A-20.

6. When swaging is completed, as indicated by pressure gage reading of 5,500 psi, set selector valve to EXHAUST to relieve pressure.

NOTE: For automatic swaging procedures refer to NAVAIR 01-1A-20.

ALTERNATE METHOD FOR PERMANENT REPAIR OF TUBE ASSEMBLIES

Automatic Induction Brazing (Depot and Industrial Application Only)

The fabrication or repair of corrosion-resistant steel tube assemblies using automatic induction brazing may be used to augment or replace the Permaswage repair method and is intended for such applications as engine-related hydraulic, fuel, oil, vent or drain lines. These assemblies, most of which already employ brazed or welded end fittings, are normally fabricated from corrosion-resistant steel supplied in the annealed condition, under one of the following specifications:

- MIL-T-8808A
- MIL-T-8606A
- MIL-T-8506A
- MIL-T-8504A
- MIL-T-8973
- MIL-T-6737B

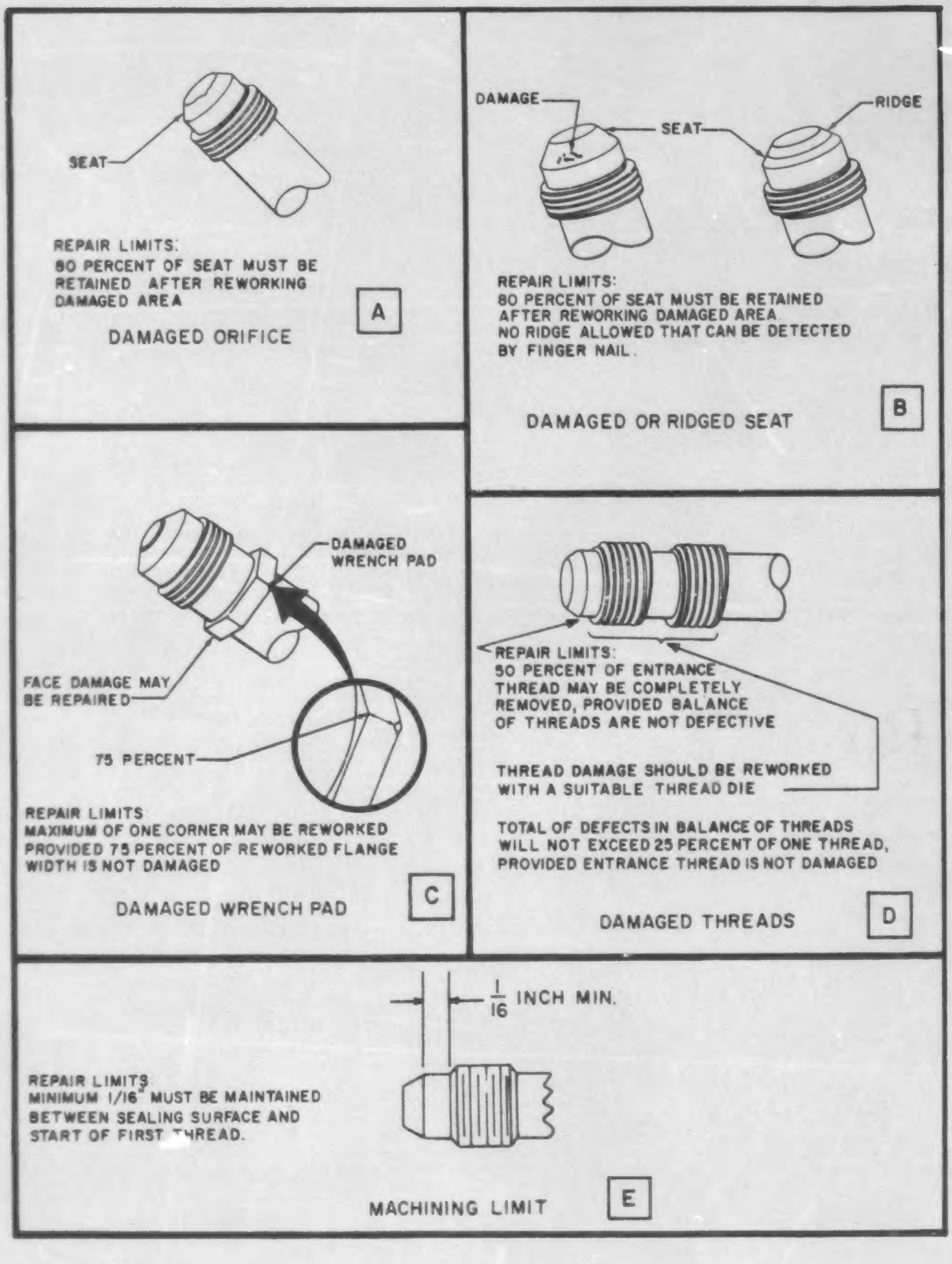
The induction brazing of tube fitting joints or splices shall be accomplished only at depot level maintenance activities or by approved vendors using automatically controlled tube brazing equipment designed for the specific purpose. All such repairs must be approved by the cognizant Naval Air Rework Facility or Naval Air Systems Command Headquarters.

REWORK OF MINOR SURFACE DAMAGE TO TUBING.–A dent less than 20 percent of the tubing diameter is acceptable provided it is not on the heel of a short bend radius. A nick which is not deeper than 15 percent of the wall thickness of aluminum, aluminum alloy, or corrosion-resistant steel is acceptable after being reworked by burnishing with hand tools. Any aluminum, aluminum alloy, or corrosion-resistant steel tubing carrying pressures greater than 100 psi which has nicks deeper than 15 percent of the wall thickness shall be repaired by other appropriate method outlined elsewhere in this section.

REWORK OF MINOR DAMAGE TO TUBE ASSEMBLY FITTINGS.–Tube assembly fittings with minor orifice damage may be handstoned to blend rough edges and burrs, provided 80 percent of the original sealing surface is retained and contains no scratches, nicks, dents, or circumferential ridges beyond acceptable limits. Orifice restrictions are removed. Fittings that retain less than 80 percent of the sealing surface shall be repaired, provided damage does not exceed repair limits. No nicks, scratches, or dents are acceptable in the critical area as shown in figure 11-16, details A and B. Circumferential ridges that can be detected with the fingernail are not serviceable. Fittings containing circumferential ridges that do not exceed repair limits may be refaced. The sealing surface shall be smooth and free from burrs, and free of longitudinal and spiral tool marks. The only marks permitted on the sealing surface are annular tool marks (one ten-thousandth of an inch, RMS). Fittings that cannot be salvaged by this method shall be rejected. Reworked aluminum alloy fittings shall be anodized. Uniform color after anodizing is not necessary. Fittings with wrench, vise-jaw, or similar marks shall be replaced. Minor scratches are not cause for replacement. If wrench damage to a hexagon section of a fitting does not exceed one corner, it shall be reworked with a fine file in such a manner as to leave no file marks. A maximum of one corner may be reworked provided 3/4 of the reworked flange width is not damaged. See figure 11-16, detail C. Damaged threads shall be inspected and repaired as shown in figure 11-16, detail D. When resurfacing the 37° sealing surface, a minimum distance of 1/16" (.063) shall be maintained between the 37° sealing surface and the start of the first thread. See figure 11-16, detail E.

All reworked fittings shall be subjected to the Fluorescent Penetrant Method of Inspection, Military Specification MIL-I-6866, or other approved inspection procedure, to ensure against cracked and unserviceable parts. After the Fluorescent Penetrant Inspection, all serviceable AN/MS fittings shall be treated for protection against corrosion. All AN/MS fittings that cannot be salvaged by this repair shall be condemned.

REUSE OF FITTINGS IN OXYGEN SYSTEMS.–When repairing an oxygen system it is permissible to reuse the old fittings after minor rework restores them to acceptable condition. After any necessary rework and prior



REPAIR LIMITS:
80 PERCENT OF SEAT MUST BE RETAINED AFTER REWORKING DAMAGED AREA

DAMAGED ORIFICE

REPAIR LIMITS:
80 PERCENT OF SEAT MUST BE RETAINED AFTER REWORKING DAMAGED AREA.
NO RIDGE ALLOWED THAT CAN BE DETECTED BY FINGER NAIL.

DAMAGED OR RIDGED SEAT

REPAIR LIMITS:
MAXIMUM OF ONE CORNER MAY BE REWORKED PROVIDED 75 PERCENT OF REWORKED FLANGE WIDTH IS NOT DAMAGED

DAMAGED WRENCH PAD

REPAIR LIMITS:
50 PERCENT OF ENTRANCE THREAD MAY BE COMPLETELY REMOVED, PROVIDED BALANCE OF THREADS ARE NOT DEFECTIVE

THREAD DAMAGE SHOULD BE REWORKED WITH A SUITABLE THREAD DIE

TOTAL OF DEFECTS IN BALANCE OF THREADS WILL NOT EXCEED 25 PERCENT OF ONE THREAD, PROVIDED ENTRANCE THREAD IS NOT DAMAGED

DAMAGED THREADS

REPAIR LIMITS:
MINIMUM 1/16" MUST BE MAINTAINED BETWEEN SEALING SURFACE AND START OF FIRST THREAD.

MACHINING LIMIT

216.265

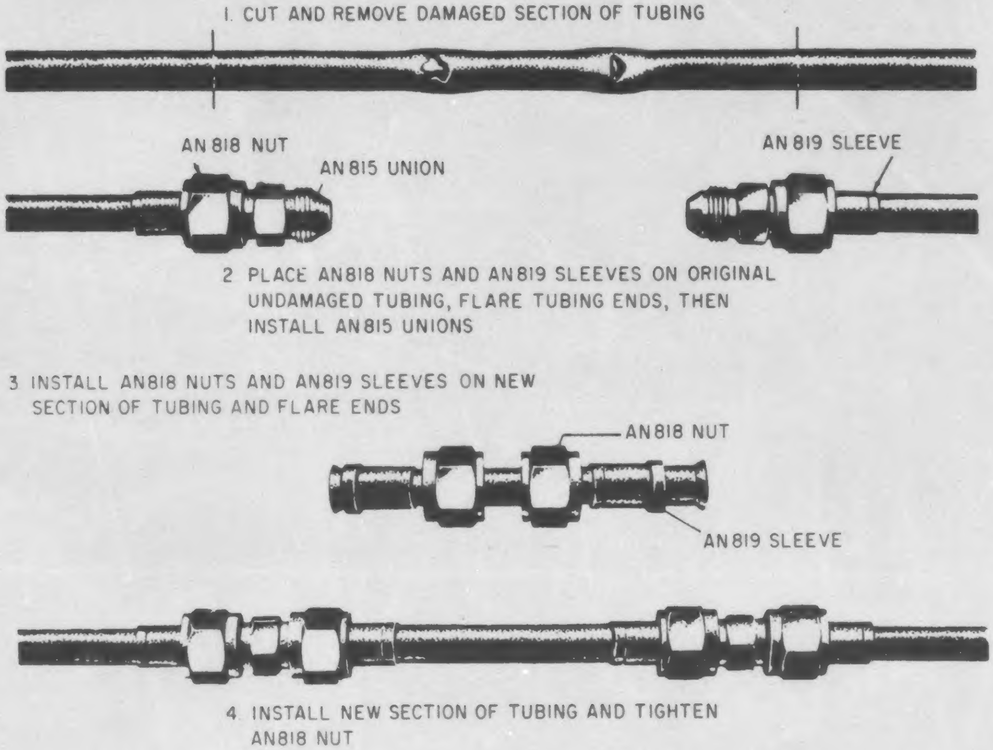
Figure 11-16.—Rework of damaged fittings.

to reinstallation, the fittings shall be cleaned. The requirements for cleaning of tubing for use in oxygen systems applies to oxygen system fittings. Refer to Section XVI, Tube Assembly Cleaning.

REPLACEMENT OF TUBE ASSEMBLIES.–When replacing a damaged tube assembly, refer to NAVAIR 01-1A-20 for aluminum and corrosion-resistant steel substitutes. Tube assemblies should be formed prior to installation. If the tubing is small and of soft material, the assembly may be formed by hand bending during installation.

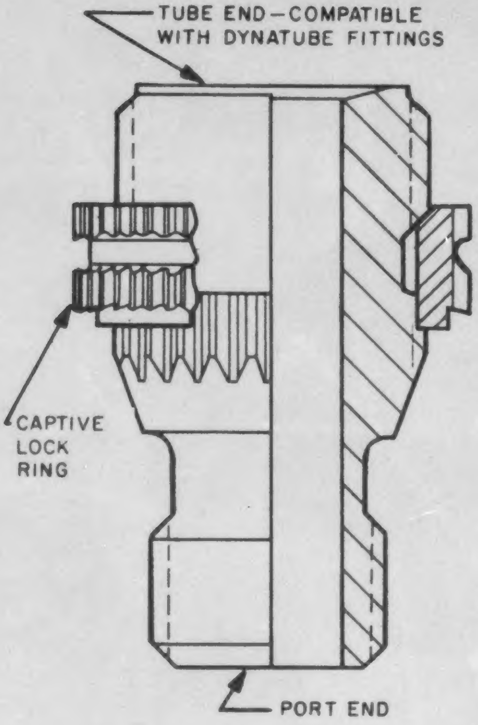
If the tubing is of such material and size that hand bending is impractical, the damaged assembly shall be removed intact, without further distortion or damage. The removed tube assembly may then be used as a forming template when fabricating the replacement. Use of a template will allow length, bends, and angles to be more accurately duplicated. If new routing is required, a new template must be made as follows:

1. Place material selected for use as a template into one of the fittings to which the replacement assembly will be connected.
2. Form required bends in template.
3. Remove template and use pattern to bend new tubing.
4. Select path with least total degrees of bend. This reduces flow loss and simplifies bending.
5. When possible, use path with all bends in same plane.


1. CUT AND REMOVE DAMAGED SECTION OF TUBING
AN 818 NUT
AN 815 UNION
AN 819 SLEEVE
2 PLACE AN818 NUTS AND AN819 SLEEVES ON ORIGINAL UNDAMAGED TUBING, FLARE TUBING ENDS, THEN INSTALL AN815 UNIONS
3 INSTALL AN818 NUTS AND AN819 SLEEVES ON NEW SECTION OF TUBING AND FLARE ENDS
AN818 NUT
AN819 SLEEVE
4 INSTALL NEW SECTION OF TUBING AND TIGHTEN AN818 NUT

216.266

Figure 11-17.–Repairing high- and low-pressure tubing.



216.267
Figure 11-18.–RF5000-13 series adapter.

6. Select path which provides for brackets or clamps to be used as supports at intervals not greater than those given in NAVAIR 01-1A-20.

Temporary Tubing Repair

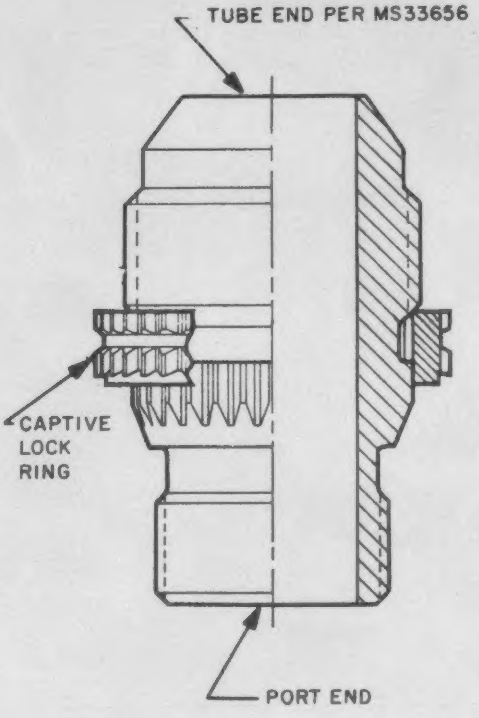
To accomplish a temporary repair of any tubing, the damaged section of the tubing shall be cut out and removed (figure 11-17). The ends of the remaining tubing shall be cleaned and the rough edges removed. If the length of the damaged section does not exceed the length of the required union, a new section is unnecessary.

ROSAN TUBE END ADAPTERS

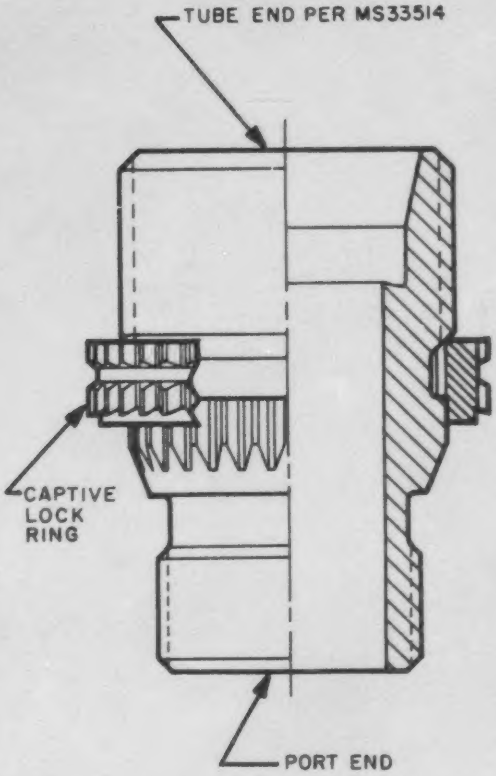
The removal and replacement of damaged Rosan fittings is authorized at all Navy maintenance levels. Three tube end adapters are available for use in the standard port (PS10035). Figures 11-18, 11-19, 11-20 illustrate these adapters.

Tools

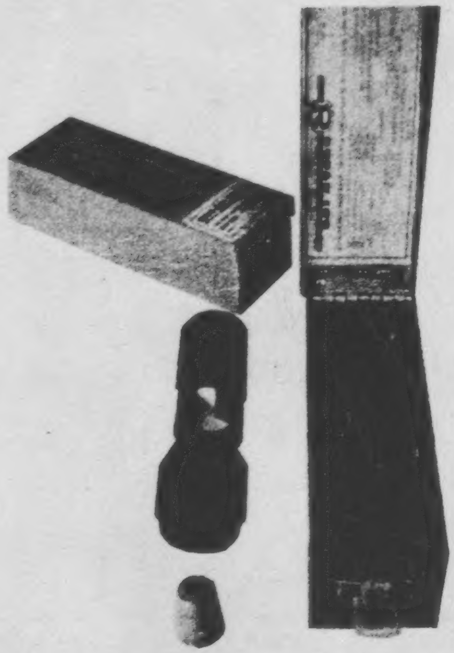
The various tools used for installing Rosan fittings are available in kit form (fig. 11-21). Each kit contains an O-ring installation tool, a combination lock ring wrench and drive tool, and a removal tool. Some fitting adapter installation kits cannot be used for removing fittings in some of the new aircraft which use the port adapter end on check valves, quick disconnects, etc. In such instances other tool kits are available; consult the aircraft handbooks for the required tool kit.



216.268
Figure 11-19.–RF9800-13 series adapter, flared.



216.269
Figure 11-20.—RF900-13 series adapter, flareless.



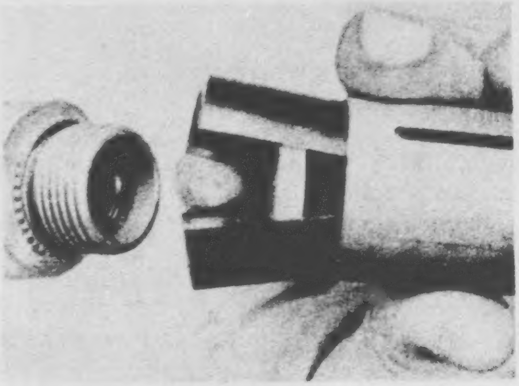
216.270
Figure 11-21.—Representative installation tool kit.

Fitting Removal

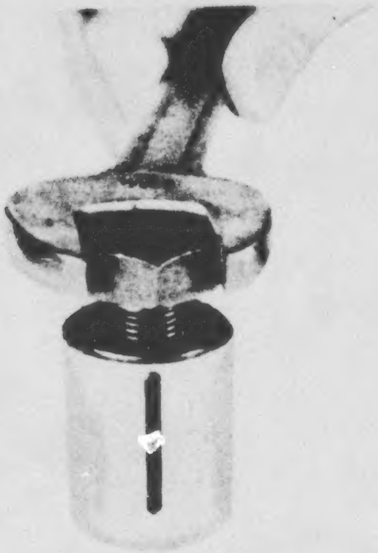
When it becomes necessary to remove a fitting adapter, the lock ring must first be removed using a lock ring puller tool (figure 11-22). Choose the proper size removal tool and proceed as follows.

1. Spread the jaw halves apart by holding them and pulling the sleeve from the assembly until the pin bottoms in the groove of the sleeve (figure 11-22).
2. Holding the puller halves apart, place tool over protruding adapter so that nylon pad rests on top surface of adapter.

3. Engage the fitting threads and turn in a clockwise direction until the jaw pulling flange is satisfactorily located in the circular groove of



216.271
Figure 11-22.—Lock ring puller tool.



216.272

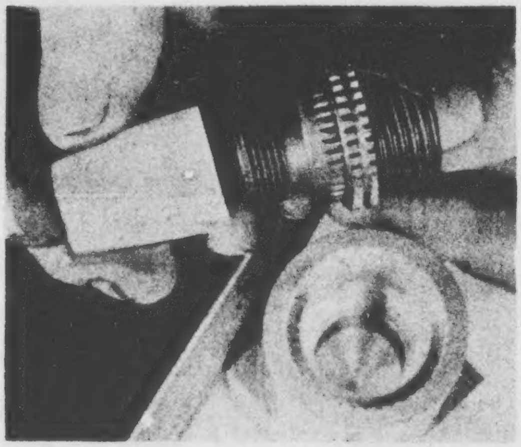
Figure 11-23.–Removing lock ring.

the lock ring. Slide the sleeve down over the jaws.

NOTE: If any resistance is noted when attempting to slide the sleeve over the jaws, check that pulling flange has engaged the circular groove of lock ring.

4. Using wrench (figure 11-23) turn bolt head in a clockwise direction, while holding sleeve with other hand, until the lock ring is pulled out of the port counterbore. When external serrations of the lock ring are clear of the port surface, remove the tool from the adapter by loosening bolt and lifting the sleeve to free the puller jaws.

5. Using the proper wrench, engage the serrations of the wrench with that of the lock ring. With an open end or socket wrench, turn adapter in a counterclockwise direction to disenagage adapter from port.



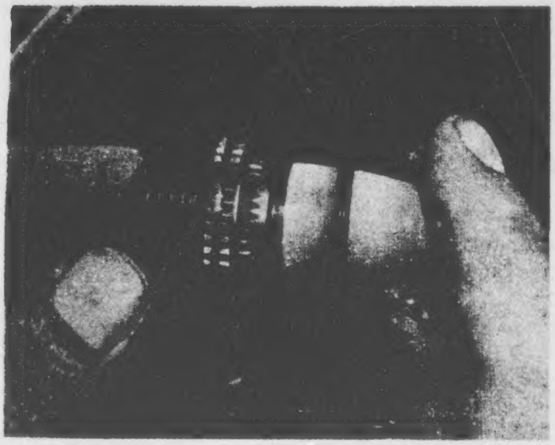
216.273

Figure 11-24.–O-ring installation tool.

Fitting Installation

Installation procedures are described in the following steps:

1. Place the Teflon bullet, or one of similar material, over the smaller thread of the fitting as shown in figure 11-24. Submerge the fitting, bullet, and O-ring in fluid to be used in working system, or a lubricant that is compatible with the system fluid. Slide the O-ring over the bullet and into the groove of the fitting (figure 11-25).
2. Lubricate the internal surfaces of the port cavity with the fluid to be used in the system or a compatible lubricant. Insert the smaller thread into the port turning by hand in a clockwise direction until the fitting is seated.
3. Using the proper combination drive tool and wrench determined by fitting size, engage the serrations of the tool with those on the external serrations of the adapter lock ring.
4. Place a torque wrench of the proper size over the hex of the wrench and apply a torque equal to the minimum value as specified in tables 11-9 or 11-10. Check the relationship of the serrations of the lock ring with respect to the broached serrations in the port. If they match, as shown in figure 11-26, proceed to step 5. If the serrations do not match the broached



216.274

Figure 11-25.—O-ring installation.

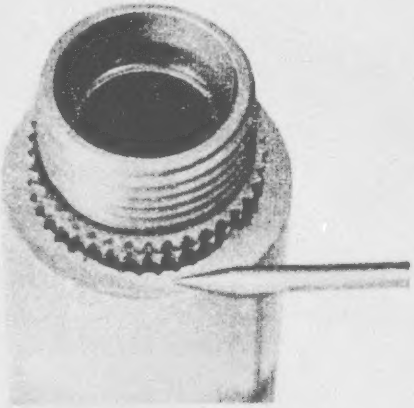
serrations in the port, continue to slowly torque the adapter toward the maximum value as specified in tables 11-9 or 11-10 until the serrations of the lock ring match the port serrations. This will normally take between 3° and 8° of turning, and the maximum torque value need not be reached if the serrations align themselves prior to that value.

5. Apply zinc chromate primer, per MIL-P-8585, with a brush or small syringe to the counterbore area of the port. NOTE: Do not allow the zinc chromate to dry.

6. To drive the lock ring, select the proper combination wrench and turn it onto the adapter (figure 11-27). Rotate the wrench until it touches the lock ring. Using an open end wrench or socket wrench on the hexagon wrenching pad, turn the tool in a clockwise direction until it bottoms on the surface of the port.

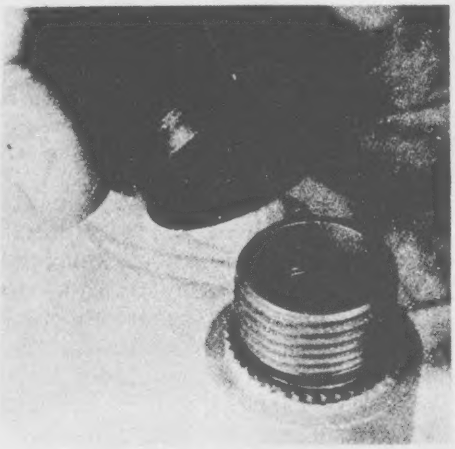
CAUTION: Any sudden increase in torque prior to bottoming may indicate that the lock ring serrations and port serrations are not aligned. If this occurs, lift the lock ring away from the boss (See removal instructions.) and align serrations as described in installation procedure, step 4.

7. Remove excess zinc chromate that has flowed onto the port surface.



216.275

Figure 11-26.—Properly matched serrations.



216.276

Figure 11-27.—Lock ring installation.

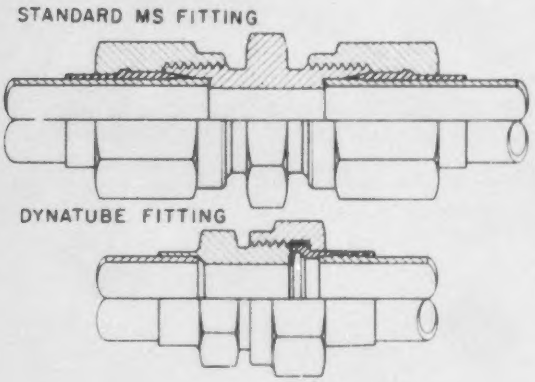
Table 11-9.—RF9800 and RF9900 series fitting installation torque values

TUBE SIZE	BASIC FITTING NUMBER (REF)	WRENCH	LOCKRING DRIVE TOOL	COMBINATION *TOOL	INSTALLATION TORQUE INCH POUNDS MIN	MAX	LOCKRING PULLER ASSY. TOOL NO.
.125	RF 9802 & RF 9902	RF 6902W	RF 9802DE	N/A	16	21	RF 9802 LPD
.188	RF 9803 & RF 9903	RF 6903W	RF 9803DE	N/A	38	45	RF 9803 LPD
.250	RF 9804 & RF 9904	RF 6904W	RF 9804DE	RF 9804 DW	60	100	RF 9804 LPD
.312	RF 9805 & RF 9905	RF 6905W	RF 9805DE	N/A	100	120	RF 9805 LPD
.375	RF 9806 & RF 9906	RF 6906W	RF 9806DE	RF 9806 DW	180	245	RF 9806 LPD
.500	RF 9808 & RF 9908	RF 6908W	RF 9808DE	RF 9808 DW	430	510	RF 9808 LPD
.625	RF 9810 & RF 9910	RF 6910W	RF 9810DE	RF 9810 DW	600	680	RF 9810 LPD
.750	RF 9812 & RF 9912	RF 6912W	RF 9812DE	RF 9812 DW	855	945	RF 9812 LPD
1.000	RF 9816 & RF 9916	RF 6916W	RF 9816DE	RF 9816 DW	1140	1260	RF 9816 LPD
1.250	RF 9820 & RF 9920	RF 6920W	RF 9820DE	N/A	1520	1680	RF 9820 LPD
1.500	RF 9824 & RF 9924	RF 6924W	RF 9824DE	N/A	1900	2100	RF 9824 LPD

*THE RF9800 DW SERIES COMBINATION DRIVE TOOL AND WRENCH IS PRIMARILY DESIGNED FOR USE WITH EITHER THE RF9800-13 or RF9900-13 SERIES OF FLUID ADAPTERS IN APPLICATIONS THAT HAVE PREBROACHED SERRATIONS IN THE PARENT MATERIAL COUNTERBORE TO ACCEPT LOCKRING.

Table 11-10.—RF5000 series fitting installation torque values

TUBE SIZE	BASIC FITTING NUMBER (REF)	INSTALLATION TOOL WRENCH & LOCKRING DRIVE TOOL	REMOVAL TOOL	INSTALLATION TORQUE INCH POUNDS MIN	MAX
.250	RF 5004-13	RF 5004DW	RF 5004 LPD	50	65
.375	RF 5006-13	RF 5006DW	RF 5006 LPD	140	200
.500	RF 5008-13	RF 5008DW	RF 5008 LPD	270	375
.625	RF 5010-13	RF 5010DW	RF 5010 LPD	620	700
.750	RF 5012-13	RF 5012DW	RF 5012 LPD	855	945
.875	RF 5014-13	RF 5014DW	RF 5014 LPD	995	1105
1.000	RF 5016-13	RF 5016DW	RF 5016 LPD	1140	1260
1.250	RF 5020T-13	RF 5020DW	RF 5020 LPD	1520	1680
1.500	RF 5024T-13	RF 5024DW	RF 5024 LPD	1900	2100



216.277
Figure 11-28.—Dynatube versus MS fitting.

DYNATUBE FITTINGS

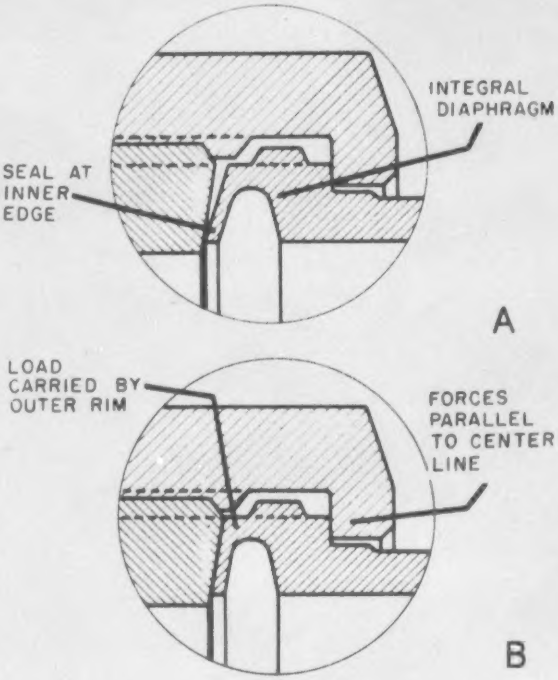
Application

The installation of Dynatube fittings on MIL-T-6845 tubing is authorized for use by all Navy maintenance levels. This section provides a detailed description of the Dynatube fitting installation techniques to provide the maintenance technician with a comprehensive understanding of this procedure.

The Dynatube fitting consists of three components as compared to five components in the standard MS fitting. As shown in figure 11-28, this new design results in only three potential leak paths as opposed to four in the MS fitting. The three components are the main connector male fitting, the nut and the new design connector female fitting with the integral diaphragm.

Specific Repairs

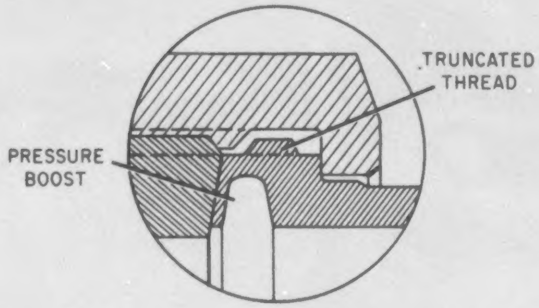
Dynatube fittings are authorized to be attached (internally swaged) on MIL-T-6845 tubing and the resultant assembly coupled to original equipment tubing in accordance with the provisions of *Aviation Hose and Tube Manual* NAVAIR 01-1A-20.



216.278
Figure 11-29.—Dynatube fitting sealing configuration.

Technique

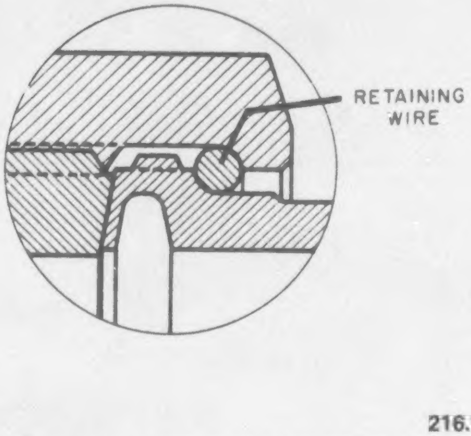
The Dynatube fitting is in a fingertight configuration before full deflection of the cantilever beam. Starring at low torque values, the pressure seal is formed at the inner edge of the beam (figure 11-29). Continuing to tighten the nut brings the angled surface of the male connector into contact with the outer rim (stop area) of the shoulder (figure 11-29B). The beam portion of the shoulder continues to seal at its inner edge, and the Belleville spring action serves as a lock for the entire union, preventing loosening. The forces built up in the union are parallel to the center line, which assures no collapse of one component into another or into the fluid stream. This also permits each area to serve its own function without being dependent on any other function. Any excess of torque will deform the nut or wrench, but will not deform the seal or affect its sealing capabilities.



216.279

Figure 11-30.–Pressure boost feature.

Another feature of the fitting is shown in figure 11-30. Pressure boost reinforces the seal at higher pressures. The truncated or semithread permits complete damage protection for the seal during storage and installation. It also allows withdrawal of the nut for fixturing of components, cooling of the beam during welding or other operations, and sideways insertion against the connector. Bore sizes are the same as in flared or flareless fittings so flow is not constricted. Figure 11-31 illustrates how the nut may be attached by use of a retaining wire in place of the truncated thread. This design also permits minimum separation clearances and tube deflection for assembly.



216.280

Figure 11-31.–Nut attached by retaining wire.

The use of high strength materials and the separation of seal and structural loads have greatly extended the permissible torque range of the fitting. With the addition of solid film lubricant on all sliding surfaces, the Dynatube fitting is capable of being assembled and disassembled at least fifty times.

Dynatube fittings may be attached to rigid tubing by welding, brazing, or mechanical swaging. For attachment to Teflon hose, the external swaged method is preferred and recommended. (See figure 11-32.) Using the swaging method, the fitting lends itself especially well for field repair. Dynatube fittings may also be used for making inplace repairs on permanent and detachable portions of a hydraulic system. (See figures 11-33 and 11-34.)

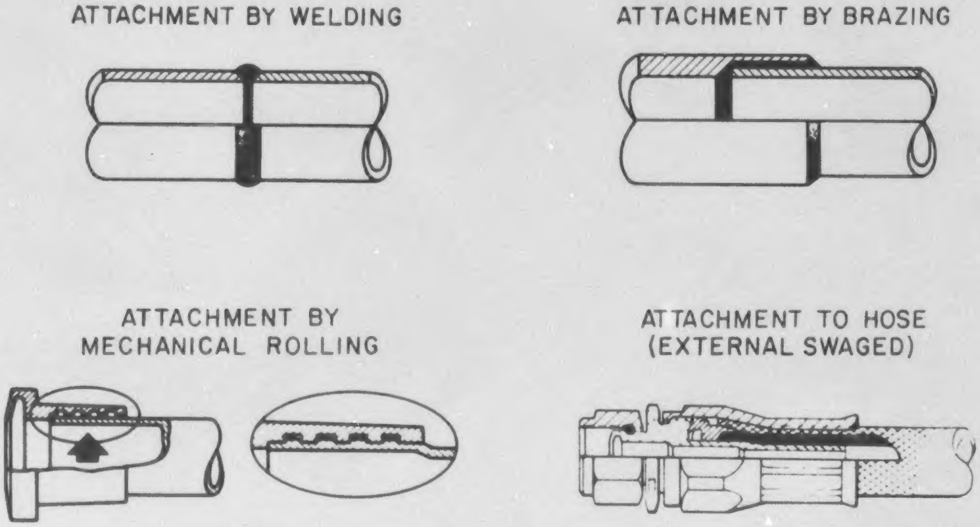
Tools

All of the tools required for mechanical attachment of Dynatube fittings are available from Resistoflex Corporation as individual sets for a given tube O.D. and wall thickness, or as kits (figure 11-35). The kits contain all basic tooling (expanders, die halves, collars, etc.) required to perform mechanical attachment of Dynatube fittings to a given range of tube sizes and wall thicknesses. All kits are supplied in portable fiberglass cases. Each tool component rests in its own Styrofoam nest to prevent damage during transit. Each kit also contains complete instructions on the use of each tool.

The tool kit shown in figure 11-35 is used for mechanically attaching Dynatube fittings to tubing by internal swaging. The procedure employs the technique of expanding the tube into specially machined grooves of the fitting, using an expander tool. Tubing and fittings are positioned and restrained with a special holding fixture. After swaging is completed, the inside diameter of the tube is checked using the gage shown in figure 11-36.

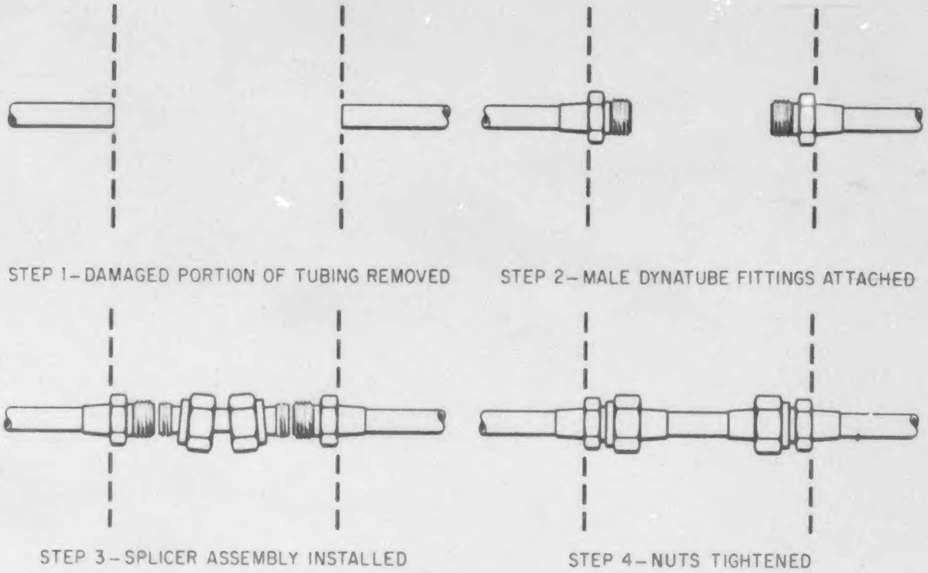
Dynatube fittings may also be attached by brazing or welding. When this method is used, precautions should be taken to ensure against high temperatures in the area of the beam sealing surfaces by the use of chill blocks.

When it becomes necessary to repair the fitting sealing surface, a connector fitting resurfacing tool is used. This procedure should


ATTACHMENT BY WELDING
ATTACHMENT BY BRAZING
ATTACHMENT BY MECHANICAL ROLLING
ATTACHMENT TO HOSE (EXTERNAL SWAGED)

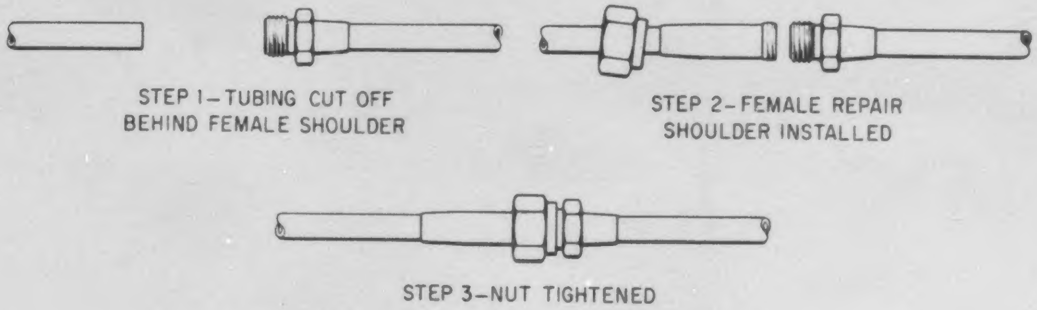
216.281

Figure 11-32.—Methods of attaching Dyantube fittings.


STEP 1—DAMAGED PORTION OF TUBING REMOVED
STEP 2—MALE DYNATUBE FITTINGS ATTACHED
STEP 3—SPLICER ASSEMBLY INSTALLED
STEP 4—NUTS TIGHTENED

216.282

Figure 11-33.—In-place repair of a permanent portion of system.


STEP 1–TUBING CUT OFF
BEHIND FEMALE SHOULDER
STEP 2–FEMALE REPAIR
SHOULDER INSTALLED
STEP 3–NUT TIGHTENED

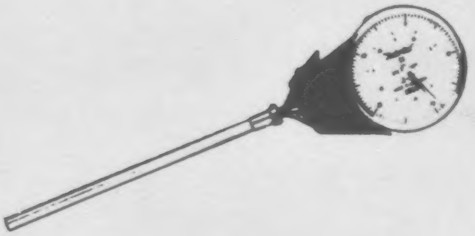
216.283

Figure 11-34.–In-place repair of a detachable portion of system.

RELIABILITY

216.284

Figure 11-35.–Field installation and repair tool kit.



216.285

Figure 11-36.—Gage for measuring swaged I.D.

be used only if the damage is minor. Should the damage be excessive, a new fitting should be installed.

Procedures for Tool Use

All tools required for mechanical attachment of Dynatube fittings are provided in the tool kit (part number R27500G-01). Based on the tube assembly to be prepared, select the correct size expander. Each expander is preset for a specific tube material and size.

All tube expanders contain an identification band which states the tool part number, the tube O.D., wall thickness and material for which the tool is designed, and the final expansion value which the tool is set to produce. The design of the tool is such that MIL-SPEC tolerances of tube O.D. and wall thickness (approximately +5%/-0% O.D. and ±10% on wall) are accommodated at the standard setting. The tools are preset at the factory, and no adjustment is required.

DIE AND COLLAR SELECTION.—Based on the fitting size and configuration, select the correct die set and collar. Check part number marked on the dies and the collars. The collar has a tapered I.D. which engages the tapered exterior of the die sets.

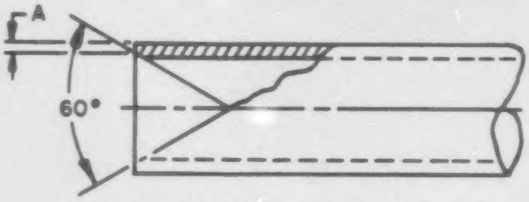
Check that tubing inserts cleanly into fitting to proper depth. Tubing can be marked for proper depth by using the dimensions shown in table 11-11.

PREPARATION OF TUBE ENDS.—Tube ends must be clean and free of oils prior to assembly. The ends must be cut square, and any end distortion, such as produced by a rolling-type tube cutter, must be removed. The O.D. should have a square edge, but a 60° chamfer is recommended on the I.D. as shown in figure 11-37.

LOCATION OF BENDS.—The physical dimensions of the Dynatube tooling require that a minimum straight length be maintained between the cut tube end and the nearest bend tangent point to provide for mandrel clearance. A minimum straight length of tube is also required to assure the presence of undisturbed cylindrical tubing at the fitting. The absolute minimum bend tangent distance must reflect the greater of these two criteria. Refer to figure 11-38 for the minimum length of straight tubing to a 25° or greater bend tangent point.

Hand Assembly Method

The following steps provide detailed instructions for mechanically attaching Dynatube fittings by the hand assembly method.



TUBE SIZE	WALL THICKNESS	A SQUARE CUT
3/16	.020±10%*	.005"
1/4	.020 10%*	.005"
3/8	.028 10%*	.015"
1/2	.035 10%*	.015"
5/8	.049 10%*	.020"
3/4	.058 10%*	.040"
1	.065±10%*	.050"

*Wall thickness MUST be verified.

216.286

Figure 11-37. Tube dimensions.

Table 11-11.–Tube insertion depths

Size	Fittings of MR44XXX Series	Fittings of MR54XXX Series
-03	.325	.325
-04	.355	.355
-05	.355	.355
-06	.355	.355
-08	.430	.430
-10	.430	.505
-12	.430	.505
-16	.505	.580
-20	.505	.656
-24	.505	.730

1. Slip the fitting onto the tube so that the tube contacts the positive stop on the inside diameter of the fitting. If a slipon nut is involved, slide the nut back down the tube so as to be out of the way of the assembly.

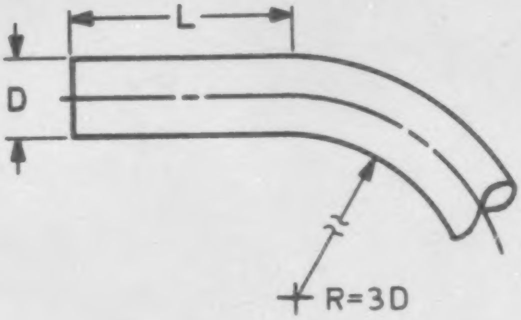
2. Lubricate the expander. For best performance, lubricate expander rollers and mandrel before each use. Use the CMD lubricant provided in the case.

3. Position the expander mandrel in the fully retracted position, i.e., with the tip of the mandrel within the expander. Insert the expander into the fitting. Position expander-tube-fitting assembly in one die set half by placing expander lip into slot of die and the fitting in the proper position. Turn mandrel clockwise until finger-tight; all components will now hold relative position.

4. Assemble second half of die set over first half. Holding assembled die halves together, slip holding collar over assembly from expander end. Tighten wing screw into "v" groove on die set, locking all components into place. Avoid positioning of wing screw over die parting line. It is recommended that the wing screw be positioned approximately 15° to 45° from the die parting line.

5. Grasp assembly by hand or hold in vise using the parallel flats of the collar as a gripping surface. Select a proper size wrench or socket-drive to mate with the square on the mandrel drive head. Turn the mandrel clockwise until the drive head contacts the stop collar and causes stop collar to turn. Continue turning for approximately ten additional turns.

6. Turn the mandrel counterclockwise until it backs out freely. Loosen wing screw, remove collar, and disassemble the die halves. Remove the expander and the tube-fitting assembly. If expander does not come out freely, lift mandrel to release roller pressure. Measure the inside diameter of swaged tube for dimension as shown in table 11-12. Clean fitting and bring nut into position over threaded shoulder. Assembly is now ready for use.



TUBE SIZE	MINIMUM ALLOWABLE LENGTH, L (INCHES)
3/16 x .020	.703
1/4 x .020	.960
3/8 x .028	.847
1/2 x .035	.968
5/8 x .049	1.000
3/4 x .058	1.000
1 x .065	1.093

216.287

Figure 11-38.–Minimum tube length versus tube size.

Table 11-12.—Tube size versus finished swage I.D.

TUBE SIZE	FINISHED SWAGE I.D. (INCHES ± .002″)
3/16 x .020	.156
1/4 x .020	.224
3/8 x .028	.335
1/2 x .035	.450
5/8 x .049	.553
3/4 x .058	.663
1 x .065	.900

TORQUING OF FITTINGS.—In order to provide proper system integrity, both flareless and flare type fittings must be properly torqued. When installing flareless fittings, use the torque values provided in the applicable Maintenance Instructions Manual or NAVAIR 01-1A-8, the *Structural Hardware Manual.* If it is not possible to utilize a torque wrench on flareless fittings, the B-nut is screwed onto the connector by hand until bottomed, then wrench-turned an additional 1/6 (1 hex flat) turn. If the fitting still leaks, an additional 1/6 turn, maximum, may be taken. Any further tightening will almost certainly cause yield and damage to the connector.

Flare type fittings are torqued to a specified number of inch-pounds based on the size of the tubing and B-nut. Figure 11-39 illustrates a representative flared tube fitting torque chart. Most charts specify a minimum and maximum torque. In such cases the middle of the torque range is the ideal torque. The torque values given apply regardless of the fitting or B-nut material. Several aircraft MIMs recommend application of antiseize material on fitting threads and flared tube ends and sleeves to prevent seizure or galling during assembly and twisting of the tubing during removal of fittings. The antiseize material should be applied to the male threads only of threaded mating parts so that no material is introduced into the hydraulic system. Figure 11-40 illustrates the recommended procedure for application of the type of antiseize material specified in the MIM.

After tightening flared or flareless fittings, apply new 1/8-inch color stripe to the fittings to indicate parts are torqued and to detect possible movement. Always remove and add new stripes on reassembly of parts. Under no circumstances should the old color stripe be used for torque alignment.

Figure 11-41 illustrates a torque wrench with the crowfoot flare nut wrench used to torque hydraulic lines. If the crowfoot is utilized in line with the torque wrench, the torque value must be recomputed as the crowfoot lengthens the arm of the torque wrench. If the crowfoot is utilized at a right angle, the torque arm remains the same and does not have to be recomputed. The method for recomputing the torque when using an extension or adapter is covered in chapter 9.

Airbleeding Systems and Components

Airbleeding of a system is required when air is known to have been admitted or is suspected of being admitted into the system. The extent of bleeding necessary to return the power system to a serviceable condition depends upon the extent to which maintenance has been performed on the power system or any of the subsystems. Normally only the subsystem in which hydraulic lines or units have been replaced or disconnected need to be bled. Bleeding can normally be accomplished by operating the subsystem at its normally rated hydraulic flow and pressure for a minimum of 5 cycles. Prior to bleeding any system, ensure that the system reservoir is full and maintained full throughout bleeding procedures. In all cases the requirement to airbleed a system following maintenance should be accomplished in accordance with the instructions provided in the applicable Maintenance Instructions Manual. A chattering of the hydraulic system is usually an indication that there is air in the system.

TUBE OD (INCHES)	"B" NUT WRENCH SIZE	5052-O AL ALLOY TUBING		6061-T6 AL ALLOY TUBING AND EQUIVALENT FLEX HOSE ASSEMBLY		SPEC MIL-T-6845 STAINLESS STEEL TUBING		ALUMINUM ALLOY TUBING FOR USE ON OXYGEN LINES ONLY	
		IN. LB MIN	IN. LB MAX	IN. LB MIN	IN. LB MAX	IN. LB MIN	IN. LB MAX	IN. LB MIN	IN. LB MAX
1/8	3/8	20	25						
3/16	7/16	25	35	30	70	90	140		
1/4	9/16	40	65	70	120	135	185		
5/16	5/8	60	80	70	120	180	230	100	125
3/8	11/16	75	125	130	180	270	345	200	250
1/2	7/8	150	250	300	400	450	525	300	400
5/8	1	200	350	430	550	650	750		
3/4	1-1/4	300	500	650	800	900	1100		
1	1-1/2	500	700	900	1100	1200	1400		
1-1/4	2	600	900	1200	1450	1500	1800		
1-1/2	2-1/4	600	900	1550	1850	2000	2300		
1-3/4	2-5/8	700	1000	2000	2350	2600	2900		
2	2-7/8	800	1100	2500	2900	3200	3600		

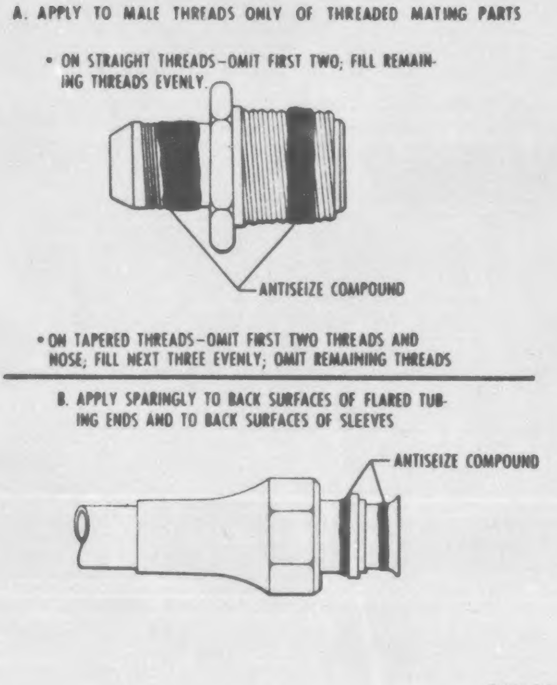
216.40

Figure 11-39.–Flared tubing and flex hose-torque specifications.

FLUID CONTAMINATION

Fluid contamination within aircraft hydraulic systems and associated ground support equipment has become a prime concern to all personnel responsible for the maintenance of such systems. The proper operation of today's close tolerance hydraulic systems demands that the cleanliness of the system be given adequate consideration during all phases of maintenance. In the past, the degree of attention given contamination prevention has varied. When contamination was established as the primary cause of an aircraft accident, there was a decided rise in attention to the problem. As time went on, the degree of attention generally tapered off and the potential for another accident was presented. Needless to say, this was a very unprofessional approach to a continuing problem. In view of the continuing demand for clean hydraulic systems, a general updating of all directives and manuals pertaining to the maintenance of aircraft hydraulic systems and related support equipment was initiated to define particle contamination levels, establish contamination control procedures and inspection requirements for all weapon systems, emphasize the sources of contamination, and, in general, provide the continued attention necessary to ensure safe aircraft operation.

Experience has shown that trouble in a hydraulic system is inevitable whenever the fluid is allowed to become contaminated. Nature of the trouble–whether a simple malfunction, or the complete destruction of a component–depends to some extent on the type of contaminant. The two general


A. APPLY TO MALE THREADS ONLY OF THREADED MATING PARTS
• ON STRAIGHT THREADS–OMIT FIRST TWO; FILL REMAINING THREADS EVENLY.
ANTISEIZE COMPOUND
• ON TAPERED THREADS–OMIT FIRST TWO THREADS AND NOSE; FILL NEXT THREE EVENLY; OMIT REMAINING THREADS
B. APPLY SPARINGLY TO BACK SURFACES OF FLARED TUBING ENDS AND TO BACK SURFACES OF SLEEVES
ANTISEIZE COMPOUND

216.41

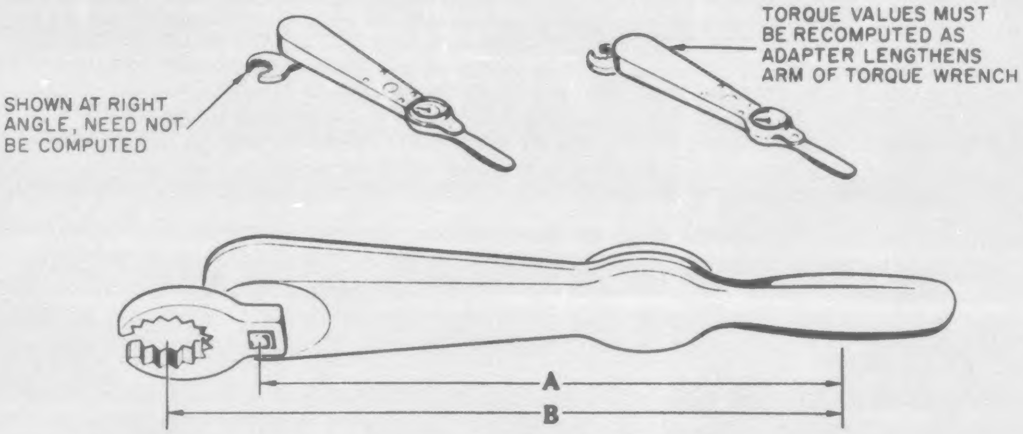
Figure 11-40.—Applying antiseize compound to flare fittings.

contaminant classes can be distinguished as follows:

1. Abrasives, including such particles as core sand, weld spatter, machining chips, and rust.
2. Nonabrasives, including those resulting from oil oxidation, and soft particles worn or shredded from seals and other organic matter.

Mechanics of the destructive action by abrasive contaminants are clear. When the size of particles circulating in the hydraulic power system is greater than the clearances between moving parts, the clearance openings retain such particles. Hydraulic pressure then embeds these particles into the softer materials, and the reciprocating or rotating motion of component parts develops scratches on finely finished surfaces. Such scratches lead in turn to internal component leakage and decreased efficiency.

Oil-oxidation products, usually called sludge, have no abrasive properties. Nevertheless, sludge may prevent proper functioning of a hydraulic system by clogging up valves, orifices, and filters. It also deteriorates certain oil qualities. Frequent changing of hydraulic system oil is not a satisfactory solution to the contamination problem. Abrasive particles contained in the


SHOWN AT RIGHT ANGLE, NEED NOT BE COMPUTED
TORQUE VALUES MUST BE RECOMPUTED AS ADAPTER LENGTHENS ARM OF TORQUE WRENCH
A
B

216.42

Figure 11-41.—Torque wrench with crowfoot adapter.

system are not usually flushed out, and new particles are continually created as friction products. Furthermore, every minute remnant of sludge acts as an effective catalyst to speed oxidation of the fresh oil.

CONTAMINATION CONTROL

OPNAV Instruction 4790.2 (Series) requires each maintenance activity to accept that area of concern for continuous hydraulic fluid surveillance applicable to its maintenance level. Of paramount importance is the thorough indoctrination and training of personnel in the prevention of contamination of hydraulic fluids, test equipment, and aircraft hydraulic systems for all levels of maintenance and aircraft repair. Each intermediate and organizational level maintenance activity is required to establish a contamination control group which will be responsible for controlling the condition and operation of all hydraulic ground support equipment, general housekeeping conditions, and aircraft maintenance practices.

Sources of Contamination

The origin of hydraulic fluid and system contaminants can be traced to four major areas:

1. Particles originally contained in the system. These particles originate during fabrication of welded system components, especially in reservoirs and pipe assemblies. Their presence is minimized by proper design. For example, seam-welded overlapping joints are preferred, and arc-welding of open sections is usually avoided. Hidden passages in valve bodies, inaccessible to sand blasting, are the main source of introduction of core sand. Even the most carefully designed and cleaned casting will almost invariably free some sand particles under the action of hydraulic pressure. Rubber hose assemblies always contain some loose particles, most of which can be removed by flushing, while others withstand cleaning and are freed later by the action of hydraulic pressure.

Lint from cleaning rags presents no abrasion danger; however, lint does have other unwelcome properties. Lint in a hydraulic system packs easily into clearances between packings and contacting surfaces, leading to component leakage and decreased efficiency. Lint also helps clog filters prematurely. Rust or corrosion initially present in a hydraulic system can usually be traced to improper stowage of materials and component parts. Particles can range in size from large flakes to abrasives of microscopic dimension. Proper preservation of stowed parts is helpful in eliminating corrosion.

2. Particles introduced from outside sources. Particles can be introduced into hydraulic systems at points where either the fluids or certain working parts of the system, (e.g., piston rods) are at least in temporary contact with the atmosphere. The most common danger areas are at the refill and breather openings, and at cylinder rod packings. Contamination arising from carelessness during servicing operations is minimized by the use of filters in the system fill lines and finger screens in the filler adapter of hydraulic reservoirs. Hydraulic cylinder piston rods incorporate wiper rings and dust seals to prevent the dust that settles on the piston during its outward stroke from being drawn into the system when the piston rod retracts.

3. Particles created within the system during operation. Contaminants created during system operation are of two general types–mechanical and chemical. Particles of a mechanical nature are formed by wear of parts in frictional contact, such as pumps, cylinders, and packing gland components. These wear particles can vary from large chunks of packings down to steel shavings of microscopic dimensions which are beyond the retention potential of system filters. The chief source of chemical contaminants in hydraulic oil is oxidation. These contaminants are formed under high pressure and temperatures, and are promoted by the catalytic action of water and air and of metals like copper or iron oxide. Oil oxidation products appear initially as organic acids, asphaltines, gums, and varnishes–sometimes combined with dust particles as sludge. Oil-soluble oxidation products tend to increase oil viscosity, while insoluble types form sediments and precipitates, especially on colder elements such as heat exchanger coils.

Oils containing antioxidants have little tendency to form gum under normal operating conditions. However, as the temperature increases, resistance to oxidation diminishes. Hydraulic fluid which has been subjected to excessively high temperatures (above 250° F) will break down in substance, leaving minute particles of asphaltine suspended in the fluid. The fluid changes from red to brown in color and is referred to as "decomposed fluid." This explains the importance of keeping oil temperatures below specified levels.

The second contaminant-producing chemical action in hydraulic fluids is one which permits these fluids to establish a tendency to react with certain types of rubber, causing structural changes in the rubber, turning it brittle, and finally causing its complete disintegration. For this reason, the compatibility of system fluid with O-rings and hose materials is a very important factor.

4. Particles introduced by foreign fluids. One of the most common foreign fluid contaminants is water. Water, which enters even the most carefully designed systems by condensation of atmospheric moisture, normally settles to the reservoir bottom. Oil movement in the reservoir disperses the water into fine droplets, and agitation of the fluid in the pump and in high speed passages forms an oil-water-air emulsion. Such an emulsion normally separates out during the rest period in the system reservoir, but when fine dust and corrosion particles are present, the emulsion is catalyzed by high pressures into sludge. The damaging action of sludge explains the need for effective filtration, as well as the need for water separating qualities in hydraulic fluids.

In summation, maintenance personnel are expected to exercise control over the three basic ways in which a system becomes contaminated, that of injecting foreign particles into the system, the intermixing of foreign fluids, and contamination that is self-generated in the system.

Control Procedures

Although it is not feasible to operate under "clean room" type conditions when performing hydraulic system maintenance, there are certain precautions which fall in the category of "good housekeeping" which will assist in eliminating the hydraulic system contamination problem. Working on hydraulic systems out in the open where there is a possibility of adverse weather conditions, exposing the system to contamination such as water, dust, etc., should be avoided.

Shop working areas utilized for hydraulic component maintenance should be clean, free from moisture, metal chips, and other clearly visible contaminants. Such work locations should logically be placed so that other maintenance being performed in the area will not expose the component to contamination from grinding or machine operations. The general requirements for clean work areas provided in the *Aviation Hydraulics Manual,* NAVAIR 01-1A-17, should be adhered to as close as possible. Shop rags utilized in hydraulic system maintenance should be of an approved type that does not leave lint.

When hydraulic lines and hose assemblies are disconnected for any reason, the openings should be immediately plugged or capped with an approved cap or plug. Lubricants applied to some O-rings during the cure date seal replacement of components should be of an approved type that will not contaminate the system.

NOTE: The only approved lubricant for hydraulic system seals is hydraulic fluid MIL-H-5606B or hydraulic fluid MIL-H-6083C. The use of petrolatum (vaseline) is prohibited, as it could be detrimental to the system.

Proper installation devices and procedures should be utilized when installing O-rings over threaded fittings.

Ground handling equipment should be approved type equipment intended for use in hydraulic system maintenance. The use of jury-rigged nonapproved type equipment is strictly forbidden. Ground support equipment should be covered by an up-to-date maintenance manual. When not in use, the cart and hose should be properly secured to protect the hose and cart from damage and possibility of contamination. The cooperation of ground support equipment personnel and AMH personnel who utilize the hydraulic test stands is mandatory in ensuring that they meet the rigid

Table 11-13.–Navy standards for hydraulic fluid

Micron	Particle contamination level--by class						
size	0	1	2	3	4	5	6
range	Number of particles/100 milliliter sample						
5 - 10	2,700	4,600	9,700	24,000	32,000	87,000	128,000
10 - 25	670	1,340	2,680	5,360	10,700	21,400	42,000
25 - 50	93	210	380	780	1,510	3,130	6,500
50 - 100	16	28	56	110	225	430	1,000
Larger than 100	1	3	5	11	21	41	92

cleanliness requirements. If a test stand is used in connection with a contaminated aircraft system and there is a possibility of equipment contamination, the equipment should be tagged to prevent its use until it can be returned to a serviceable condition.

Servicing of hydraulic reservoirs must be accomplished with an approved dispenser so that fluid being introduced into the system is not contaminated and the manner in which the servicing is accomplished does not introduce contaminants.

In all cases of hydraulic system maintenance, it is essential that the instructions and precautions provided in the Maintenance Instructions Manual be followed.

In order to ensure the cleanliness and the purity of fluid in the hydraulic system, fluid checks should be made in accordance with the MIM, inspection requirements, or any other directive that may require such action based on a specific period of time or conditional factors. The frequency of such checks will vary, depending on the type of aircraft, operational environment, the amount of maintenance performed on the system, and other factors. The condition of the fluid will largely depend on the condition of components in the system. If an unusual amount of servicing and component replacement was necessary in a certain system, the condition of the fluid will generally have suffered proportionately.

Hydraulic fluid contaminants are measured in size by microns. The micron measurement provides a convenient system for measuring the quantity of particles in a system by size groups. The level or range of contamination is measured in terms of the quantities of particles present in 100 milliliters of fluid. The contamination levels for each class are provided in table 11-13. Class 5 or lower is the acceptable contamination level established for aircraft hydraulic systems and related ground support equipment.

Contamination Analysis

To determine the level of contamination, a representative quantity of fluid must be removed from the system and subjected to analysis. Specific details of how, when, and where fluid sampling can be accomplished are found in the aircraft or support equipment Maintenance Instructions Manual and/or Maintenance Requirements Cards. The method of obtaining the sample of fluid from the system is most important in obtaining a sample which will provide an accurate analysis of the true condition of the system. Future procurements of aircraft will require that they be equipped with suitable sampling valves that will alleviate breaking into the system to obtain a sample with the resultant possibility of contaminating the system further. Present sampling valves in use on Air Force and commercial aircraft are installed at specified points throughout the hydraulic plumbing in the aircraft so that a sampling of fluid can be withdrawn from isolated sections of each system. The sampling valves are attached to a probe facing upstream in the pressure and/or return lines, allowing the sample of fluid to be withdrawn from the middle of the flowing stream.

The sampling valve is basically a labyrinth restrictor, whose effect is that of a long narrow pipe, so that the velocity of fluid is low. To minimize the possibility of contamination during sampling operations, the opening and closing mechanism of the valve consists of two plates which are compressed or separated by spring force. This design provides a minimal loss of fluid and is extremely effective from a cleanliness point of view.

Until airframe changes require modification of present aircraft systems to accommodate sampling valves, the most common sampling procedure will require removing a hose, cracking a B-nut, or some similar action as specified in the MIM. The means to detect contamination in fluid and identify it to a particular level has been provided by utilizing the Patch Test Analysis Kit, P/N 57L414, and the related instructions supplied with the kit. The kit is shown in figure 11-42.

The two wash bottles are identical, except that one has a shorter tip to accommodate the Swinnex filter unit. This bottle is used to dispense filtered solvent when performing analysis of the hydraulic fluid or rinsing bottles in preparation for taking fluid samples. The other wash bottle is used to flush fittings on the aircraft at sampling points to prevent external contamination and a resultant false analysis. The stainless steel forceps are provided for handling the filter patches. The Swinnex filter unit is threaded and in two parts.

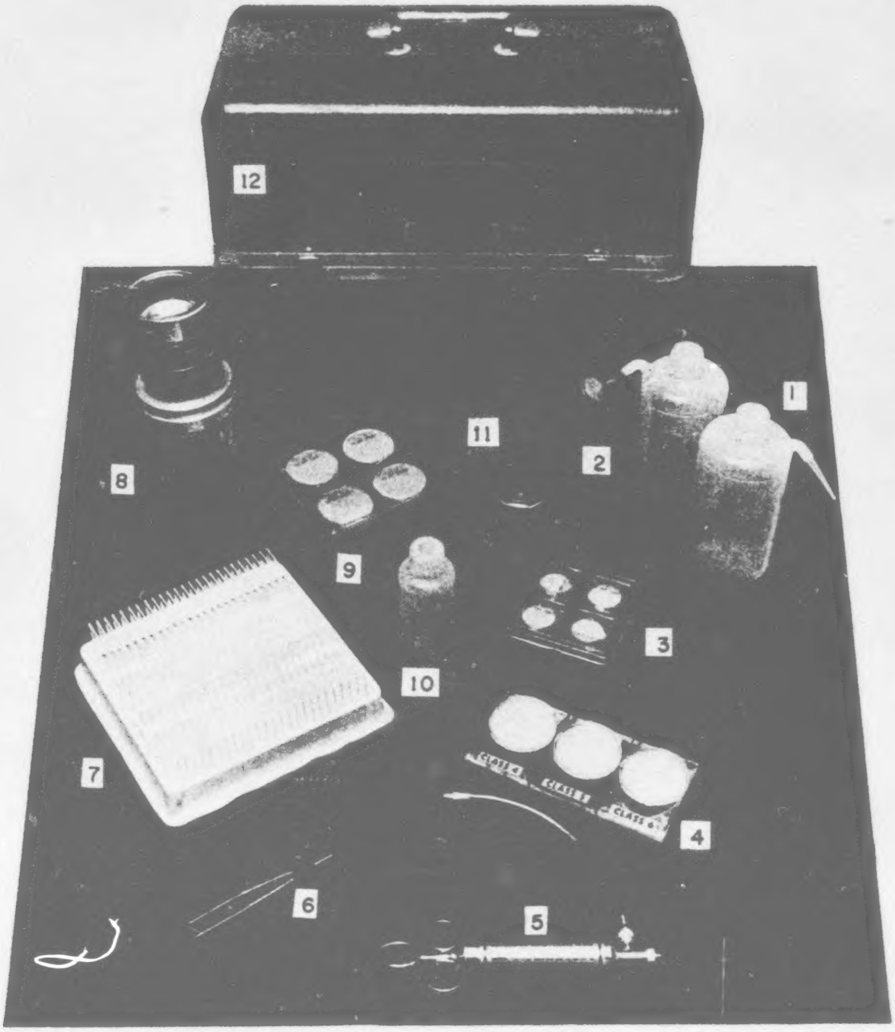
In preparing the bottle for use, disassemble the filter unit and place one white filter patch on the perforated surface and reassemble fingertight. The filter patches are separated by blue discs in their container, and the discs should be discarded before installing the filter patch. Fill the bottle with the Swinnex filter with Freon solvent, -MIL-C-81302, Type II, and replace the screwcap. Freon is the preferred solvent for analysis because it evaporates more readily and patches dry more rapidly. P-D-680, Type I, drycleaning solvent may also be used for analysis work if the additional drying time can be accommodated. By closing the hole in the cap of the bottle with the ifnger and squeezing the bottle, filtered solvent will be delivered as required. If the filter unit is forced on the wash bottle too tightly, the tip of the bottle may be damaged. Should this happen, the other wash bottle may be modified by cutting the tip off with a sharp knife or razor blade so that it will accommodate the Swinnex filter unit. The damaged bottle may then be used for general flushing of sampling fittings.

Prior to taking a sample, wipe off the fitting or component which is to be sampled, using disposable wiping cloths and rinsing with clean drycleaning solvent, dispensed from the plastic wash bottle. Clean JP-5 jet engine fuel may be used as an alternate solvent; however, the drycleaning solvent, P-D-680, Type I is preferred. Loosen the sampling connection and allow fluid to flow from the connection. Flush off the fitting again, allowing a moment for the solvent to drain. Loosen the cap of the sampling bottle and have it ready to collect a sample. Complete the disconnection and allow a portion of hydraulic fluid to flow from the sampling connection before taking the sampling. Collect at least a 4-ounce sample in the bottle. Replace the cap on the sample bottle and label the bottle to identify the equipment or aircraft model number, serial number or bureau number, and the source of the sample.

If the sampling of fluid is taken from a filter bowl where less than 4 ounces is available, collect as much as possible. Continue the sampling and labeling of each sample until all necessary points of the service unit or the aircraft have been sampled.

The samples are filtered and examined for contamination in the following manner:

1. Assemble the filter holder assembly as shown in (8) of figure 11-42. Connect the plastic



1. Bottle, wash, polethylene, 500 milliliter (ml); tip modified on one to accept Swinnex filter holder.
2. Swinnex filter holder.
3. Filters, white, plain, 25mm.
4. Standard, hydraulic fluid contamination patches.
5. Syringe, metal with two-way valve.
6. Stainless steel forceps.
7. Petri-slides.
8. Filter holder assembly.
9. Filters, white, plain, 47mm.
10. Bottle, polyethylene, 4 oz., narrow-mouth (sampling bottle).
11. Cylinder, graduated, TPX.
12. Contamination analysis kit.

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Figure 11-42.–Contamination analysis kit.

hose (5) to the side of the filter flask and to the vacuum (intake) side of the syringe (5).

2. Unlock the filter funnel (8) and install a clean filter patch (9), using the stainless steel forceps (6). Be sure to remove the blue separators. Lock the funnel assembly and pour approximately 25 milliliters of filtered Freon solvent into the funnel.

3. Mix the sample by inverting the bottle several times. Measure 100 milliliters of oil sample into graduated cylinder (11) and pour into the funnel containing the 25 milliliters of Freon solvent. Begin filtering by pumping the syringe. This creates a good vacuum which will hold for several minutes.

4. Rinse the cylinder with 50 milliliters of solvent to remove all residue and pour into the funnel. Repeat, using another 50 millileters of solvent. Apply more vacuum by pumping the syringe as required.

5. While some liquid remains in the funnel, wash down the sides of the funnel with filtered solvent from the squeeze type wash bottle. Do not direct the spray from the wash bottle directly onto the filter patch.

6. Apply vacuum again and dry the filter for 2 to 3 minutes. Remove the filter patch and allow to dry in still air in an uncovered petrislide (7). Cover the patch, label, and evaluate. Whenever drycleaning solvent P-D-680 is used as the filtered solvent, patches must be allowed to dry thoroughly before putting them in the petri-slide; otherwise, the slide will craze and cloud.

(Steps 7 & 8 detail the evaluation of the samples.)

7. Samples are usually taken from specified filter bowls and from system reserovirs. Filter patches from filter bowls will generally be evaluated for the presence of metal and for types of nonmetal contamination. Reservoir samples will generally be evaluated against an SAE Class 5 standard patch only. All systems should be examined for water. Water on the filter patch will appear as a droplet or in some cases will disperse and be apparent as a clear spot.

8. Examine filter patches and evaluate for visible metallic and nometallic particle contamination to determine if the system meets the requirements as specified for the specific aircraft and/or GSE system. Compare the appropriate filter patches with the standard patches (4) provided with the kit. Systems whose patches are darker than the Class 5 standard patch are unsatisfactory. Systems whose patches are equal to or lighter than the Class 5 standard are acceptable.

If a system is unsatisfactory, decontamination and resampling must be accomplished in accordance with the specific directives applicable to the aircraft model or item of ground support equipment.

If automatic particle count equipment or microscopic particle count equipment is available, it may be used to analyze fluid samples in lieu of the Contamination Analysis Kit 57L414. Since there are a variety of automatic particle counters, it is not considered feasible to describe them in detail in this chapter.

SYSTEM DECONTAMINATION

Experience has shown that dedicated attention to hydraulic system cleanliness and decontamination procedures can produce a cleaner hydraulic system in the aircraft as the aircraft is operated. Naturally this is only true if components of the system are not adding new contamination at a rate greater than that which the filtering system can handle. Improved cleanliness provides longer component life, improved system reliability, and increased availability of both aircraft and support equipment.

The procedures to be used in returning a system to a serviceable condition will be dependent on the extent of contamination. There are basically three terms commonly referred to in regard to system cleaning. The definitions of these terms, discussed in the paragraphs to follow, have been adopted as standard throughout the Navy. Previously, the variety of Maintenance Instructions Manuals and directives utilized these terms in a conflicting manner.

Recirculation Cleaning

Recirculation cleaning is a decontamination process in which the aircraft hydraulic systems are powered from a clean external power source and cycled so as to produce a maximum displacement of fluid. Decontamination is accomplished by circulating the original aircraft fluid through the aircraft and GSE filters (replacing or cleaning these filters as required) throughout the cleaning operation until the system level of contamination has been reduced to an acceptable level. Since the filters in all ground test stands have a 3-micron filtration system and the requirement for the aircraft system cleanliness is 5 microns or less, it is apparent that repeated cycling of fluid through the aircraft filters and the support equipment filters will gradually reduce the contamination level.

In general, careful recycling,along with filter changes before and immediately after flight of the aircraft, has been recognized as an effective way to correct a less serious contamination problem to the point where the aircraft filtration system can then continuously hold it to an acceptable level. The recycling cleaning process is effective, provided that system components are good and are not introducing new contaminates beyond the capacity of the aircraft's filters.

Flushing

The flushing process is one in which the original aircraft fluid is removed to the maximum extent practical and discarded. The draining operation is generally performed with the system connected to a clean external hydraulic power source with new fluid being introduced into the system as the old fluid is forced out or after it has been drained.

On some aircraft hydraulic systems attention will have to be given to certain trapped fluid areas. One way to detect fluid that does not readily displace during the flushing operation is checking the lines in suspected areas. The relative coolness of lines in those areas can be considered a reasonable indicator. Fluid in the hydraulic pump and lines leading out of the pump to the quick-disconnect fitting for external power application is one area that can be easily overlooked. Lines in such areas will have to be disconnected and drained in order for the flushing to be complete. Some aircraft have drain valves installed in many such areas to accommodate draining of such contamination accumulation points. In any case a distinct maintenance effort will be required to ensure that as much contaminated fluid as possible is replaced by the flushing operation.

The occasion for flushing an entire system will generally be rare. When contamination from an outside source is discovered, immediate action to prevent the spread of the contamination throughout the system can be directed at localized areas rather than the whole system. It would be necessary to take a sampling of fluid from connecting locations to ensure that the contamination was in fact isolated to that localized area.

Purging

Purging is considered an extreme procedure and is normally used only when the aircraft is positively established to be severely contaminated. An example of the necessity for purging would be where a foreign fluid is introduced into a system and causes system fluid to degrade and cause gummy, jellylike by-products to form in components and system plumbing.

The purging process involves draining the aircraft hydraulic system to the maximum extent possible and discarding the fluid. The system is then filled with a suitable cleaning agent which is circulated as effectively as possible through the system so as to remove gross contaminants. The operation is completed by removing the recirculated cleaning agent and replenishing the system with new hydraulic fluid and new or cleaned filters. The purging process will almost always require the removal and individual cleaning of many components. Purging is usually followed by a period of recirculation cleaning to ensure adequate decontamination. In all cases the decontamination success is verified by resampling and analysis.

AEROSPACE GROUND EQUIPMENT (AGE)

There is a large variety of support equipment designed to meet the needs of the maintenance man when performing hydraulic system maintenance. Many of these pieces of equipment are described in chapter 10 of *AMH 3 & 2.* It is the intent of the coverage provided in this chapter to emphasize the proper use of such equipment and point out the capabilities of some of this equipment that is occasionally not utilized to its full potential.

The terms ground support equipment (GSE) and aerospace ground equipment (AGE) are used synonymously throughout this chapter and in many Maintenance Instruction Manuals, depending on the aircraft manufacturer and joint service utilization of the type aircraft.

HYDRAULIC SERVICING UNIT

A prime consideration in servicing any hydraulic system is to introduce only pure uncontaminated fluid. The Loe H250-1 servicing unit, illustrated in figure 11-43, provides the means of servicing a system by pumping fluid directly from the original container without exposing the fluid to open air or other atmospheric contamination. It has the added advantage of not wasting hydraulic fluid when only a partial can is needed to top off a system. The remaining fluid can be retained in its contamination-free container in the unit and used at a later time.

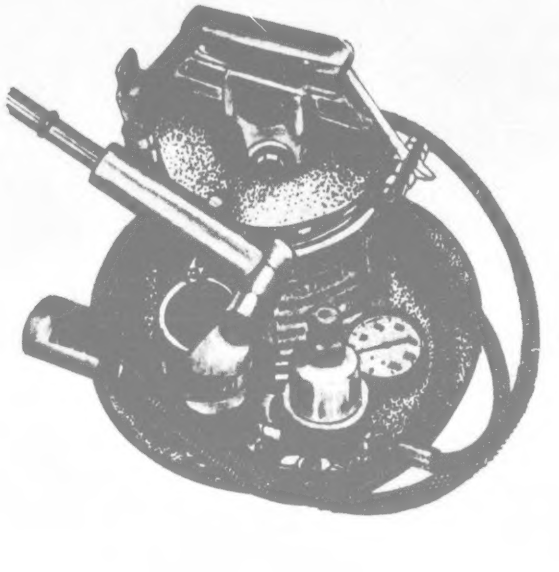

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Figure 11-43.—Hydraulic servicing unit-Loe H250-1.

The new unit is received in an unpainted condition, and it is intended that it remain that way. This lack of paint eliminates the possibility of paint chip contamination which has been found in hydraulic systems serviced with less sophisticated servicing units. Exposed steel parts are plated, and aluminum parts have a hard anodized finish to withstand the environmental conditions to which it may be subjected throughout its life. The base of the unit has a neoprene strip bonded around it to prevent the unit from sliding on up to a 15-degree slope and to prevent scratching of any surface, thus destroying corrosion protection.

The 3-micron filtration provided by the servicing unit prevents contamination of a system by new fluid that may not meet the prescribed cleanliness requirements prior to packaging. While the possibility of pre-canned contamination is rare, it has occurred. The most outstanding feature of the servicing unit is that the original container is the reservoir and is not opened until placed in the unit and the handle assembly is pressed into the locked position. When the handle is locked, the can is sealed into the unit and cleanly pierced top and bottom, automatically destroying the can's potential for future reuse. The top piercing pin is drilled to provide an atmospheric vent for the can. The vent is protected from the entrance of airborne contaminants by a 5-micron filter, located under the handle, and a check valve. The check valve remains closed except when the unit is dispensing fluid, minimizing the possibility for moisture contamination.

The lower piercing pin is also drilled and provides a means for the hydraulic fluid to reach the pump via the drilled passage in the base casting and a 3-micron filter. This filter is a nonbypass type which renders the unit inoperative if it becomes clogged. Additionally, the filter holder is designed so that the pump will not operate if the filter is inadvertently left out or the wrong type is installed. Location of the filter on the upstream side of the pump is unusual, but several distinct advantages are provided.

The filter is subjected to approximately 14 psi pressure. This pressure is insufficient to collapse the filter element even if it is clogged. Thus the filter may be made of less costly semirigid disposable material.

The filter housing and pump chamber are made as one casting with integral check valves and a pressure relief valve which is set at 250 psi. The air trap and bleed valve, pressure gage, and the pressure shutoff and relief valve are attached directly to the pump housing. Normal operation of the air trap is simple. If air enters the pump pressure chamber, as it may when installing a new container of fluid, it is compressed into the air chamber of the air trap and does not allow sufficient fluid pressure buildup to overcome the downstream check valve. Consequently, air will cycle back and forth between the pump and the air trap until it is bled off through the bleed valve. The bleed valve is spring-loaded closed. A one-quarter turn clockwise, using finger pressure only, will relieve the trapped air as the pump is actuated.

The pressure shutoff and relief valve is located on the bottom of the air trap chamber. With the valve's handle in the upright position, pump pressure buildup will remain in the servicing hose and be indicated on the pressure gage. Rotation of the handle toward the pump will relieve hose and gage pressure. The service hose is 8 feet long and has a 5-micron inline filter installed at the service end to prevent reverse contamination through the hose.

Since the variety of naval aircraft utilize different size disconnects on reservoir servicing inlets, no standard size was provided on the unit. Each activity must provide the particular disconnect. Both the male and female portions should be purchased so that one portion can be installed on the hose fitting and the other half on the bracket provided. By mating up the disconnect halves when the unit is not in use, a perfect store arrangement for the hose is realized and the last possibility for contamination is eliminated.

It should be obvious that the Loe H250-1 service unit has been designed with the Navy's goal of achieving superclean hydraulic systems in mind. This exceptional design will remain effective only as long as all operators respect its proper use.

MODEL HSU-1 FLUID SERVICE UNIT

The Model HSU-1 Fluid Service Unit, illustrated in figure 11-44, is similar in operation to the Model H-250-1 except that it has a fluid-holding capacity of three gallons. Like the Model H-250-1, this unit also accepts a standard one-gallon container and uses it as a fluid reservoir but, in addition, it contains an integral two-gallon reservoir assembly. Three-micron filtration is incorporated to ensure delivery of contamination-free fluid. A means is provided for manual deaeration.

The integral two-gallon reservoir assembly is anodized cast aluminum and, along with a hand pump assembly, is mounted to a cast aluminum base. The lower of the two can piercers (refer to figure 11-44) is mounted on top of the reservoir and allows fluid to flow from the installed one-gallon container into the reservoir, automatically replenishing it. A tubular sight gage of clear plastic indicates the fluid level of the reservoir. It is calibrated to read from 0 to 2 gallons in 1/4-gallon increments. An indicated level of 2 gallons or less denotes that the one-gallon container is empty and can be removed for replacement. A capped deaeration port is located on top of the reservoir to permit bleeding the air from the pump and output hose when necessary.

Can holder and handle assemblies are mounted above the two-gallon reservoir.The can holder serves to position the installed one-gallon fluid container and also provides a means of locating the handle assembly over the container top. The handle assembly is hinged to a bracket on the can holder assembly and is provided with a spring-loaded latch to lock the handle in the closed position. In addition to the carrying handle itself, the handle assembly contains an upper can piercer, a vent check valve, and a filter. A vent hose is connected between the top of the reservoir (sight gage) and the upper can piercer.

Fluid is delivered by means of a single-action piston type hand pump having a displacement of 1.5 fluid ounces per full stroke at 0 to 250 psi.

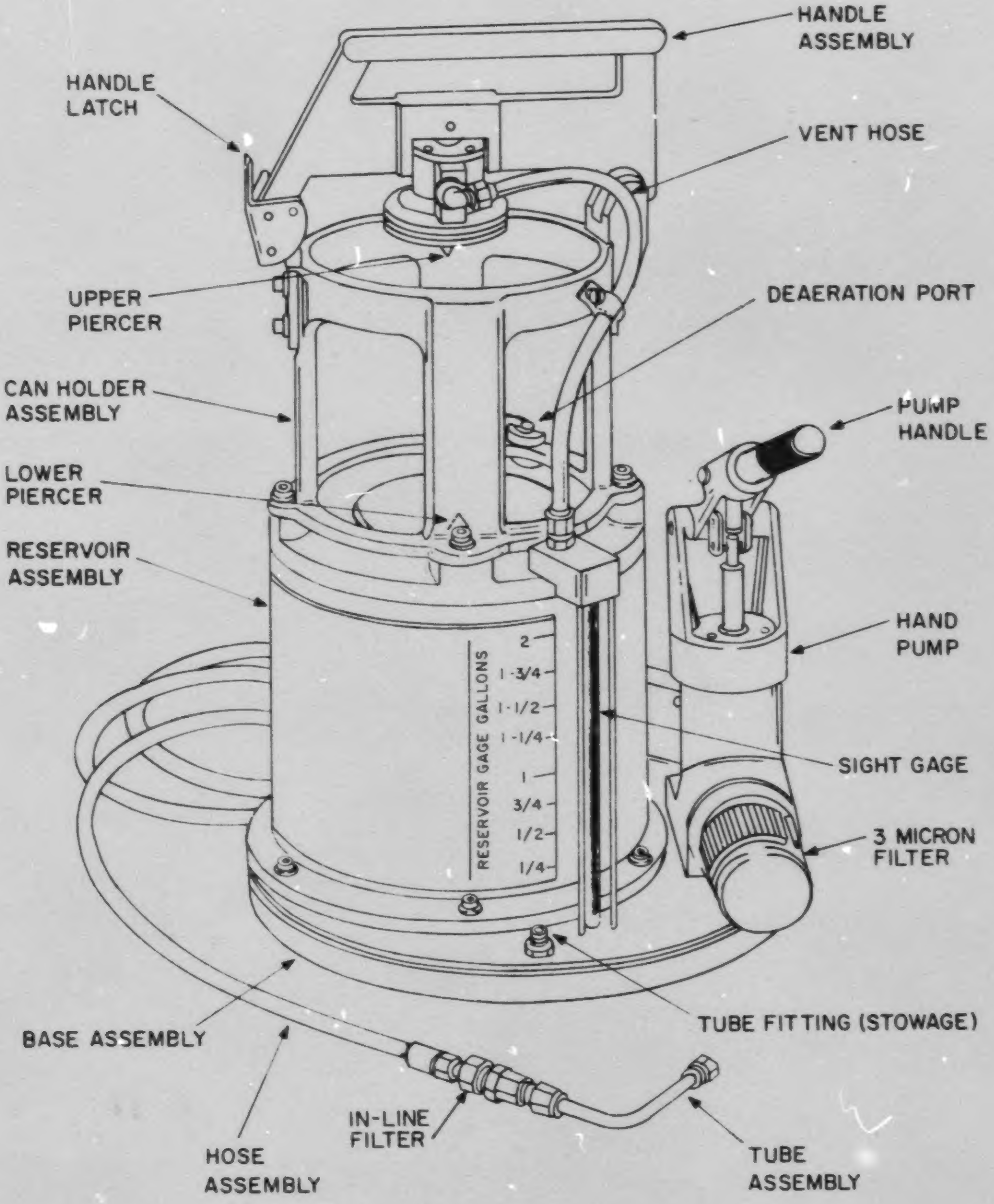
HANDLE ASSEMBLY
HANDLE LATCH
VENT HOSE
UPPER PIERCER
DEAERATION PORT
CAN HOLDER ASSEMBLY
PUMP HANDLE
LOWER PIERCER
RESERVOIR ASSEMBLY
HAND PUMP
RESERVOIR GAGE GALLONS
2
1-3/4
1-1/2
1-1/4
1
3/4
1/2
1/4
SIGHT GAGE
3 MICRON FILTER
TUBE FITTING (STOWAGE)
BASE ASSEMBLY
IN-LINE FILTER
HOSE ASSEMBLY
TUBE ASSEMBLY

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Figure 11-44.—Model HSU-1 fluid service unit.

The pump is operated with a sliding pump handle which is held in the extended or retracted position by a spring-loaded ball detent. A replaceable 3-micron disposable filter on the pump base removes particulate contamination from the hydraulic fluid being delivered to the suction side of the pump. The filter unseats a shutoff valve which closes the suction port whenever the filter element is being replaced.

The HSU-1 is equipped with a 7-foot service hose which is connected to the unit's fluid output port at the pump assembly. The hose assembly terminates with a short bent-tube assembly which provides for direct connection to fill fittings on the aircraft or components being serviced. A 2-micron (nominal) in-line filter located between the hose end and the tube prevents reverse-flow contamination and serves as a final filter. When the fluid service unit is not in use, the hose assembly is wrapped around the can holder assembly and the tube end fastened to a bulkhead fitting on the base for stowage.

PORTABLE HYDRAULIC TEST STANDS

The operating procedures and a complete description of the AHT-63, electric-motor-driven hydraulic test stand, and the AHT-64, diesel-engine-driven hydraulic test stand, are provided in the *AMH 3 & 2 Rate Training Manual,* NAVEDTRA 10310-B and are not repeated in this manual.

AMH personnel who are charged with the responsibility of such test stands should ensure that each stand meets the standards of cleanliness for use in servicing aircraft hydraulic systems and that they are consistently maintained to provide satisfactory operation.

All operators as well as supervisory personnel responsible for such equipment should be qualified and licensed prior to operating the equipment. Unqualified operators present a potential hazard in terms of safety and the possibility of damage to equipment and the aircraft being tested. GSE operators are required to have a valid operator's license in their physical possession when operating any equipment.

Personnel in the AS rating are responsible for the correction of malfunctions of a serious nature on support equipment which is on subcustody from the supporting activity. However, the test stand operator should be thoroughly familiar with the operating characteristics of major components in order to recognize and remedy ordinary faults due to incorrect operating procedures or component malfunction. Table 11-14 provides a representative example of the troubleshooting guides found in the Operation, Service and Overhaul Instructions published for each item of support equipment. Copies of pertinent manuals should be maintained in each activity's master technical library. Table 11-14 is the troubleshooting guide for the AHT-63 and, properly utilized, it will enable the operator to identify and locate troubles and take the necessary corrective action. It should be stressed that any evidence of malfunction, however minor in nature, should be corrected before it develops into a serious malfunction that could render the equipment inoperative for lengthy and costly repairs. Strict compliance with daily and periodic maintenance requirements should provide the expected level of equipment availability.

ULTRASONIC FILTER CLEANER/TESTER

The Navy presently utilizes a considerable number of reusable micron type filters in its aircraft and support equipment hydraulic systems. Early methods of cleaning these filters consisted of rinsing the filters in clean solvent, backflushing, or other similar methods that are considered totally unsatisfactory in meeting the standards of cleanliness necessary for safe operation of today's hydraulic systems.

The 3,000-psi system lodges minute particle contaminants simultaneously with varnish accumulations in the filter so solidly that removal is almost impossible without specially designed equipment.

Micron type filters such as the cutaway design shown in figure 11-45 consist of finely woven stainless steel wire mesh, accordion pleated and formed into the shape of a cylinder. This fine wire mesh is supported by a coarse mesh, which prevents the fine mesh from collapsing, and a perforated center metal tube

Table 11-14.—Troubleshooting guide—AHT-63 hydraulic test stand

Trouble	Probable cause	Possible remedy
FAULT INDICATIONS AND TROUBLES		
High pressure filter indicator lights	Clogged high pressure filter.	Clean high pressure filter. Clean or replace secondary element.
Pump case filter indicator lights.	Clogged pump case filter.	Clean pump case filter.
Low pressure filter indicator lights.	Clogged low pressure filter.	Clean low pressure filter.
High fluid temperature indicator lights.	Defective temperature gage.	Replace.
	Temperature controller improperly set.	Adjust temperature controller.
	Defective thermoswitch.	Replace thermoswitch.
STARTING PROCEDURE TROUBLES		
Power on indicator does not light; no power to control panel.	Voltage overload has opened circuit breaker CB1:	Turn circuit breaker CB1 ON. Check for proper voltage input.
	Voltage overload has blown fuses F1 and F2.	Replace fuses F1 and F2.
	Open circuit.	Check circuitry.
	Defective lamp in indicator DS9.	Replace defective lamp.
Electrical drive motor does not start.	No electrical power.	Check remedies listed above.
	Improper phase sequence.	Correct phase sequence; press overload reset button.
	Low boost pressure.	Check for malfunction of low boost pump and low boost pressure switch.
OPERATING TROUBLES		
Hydraulic pump fails to deliver sufficient volume.	Incorrect setting of pump volume control.	Set pump volume control correctly.
	Bypass valve open.	Close bypass valve.
	High pressure relief valve or compensator set too low.	Correct setting of high pressure relief valve.

Table 11-14.–Troubleshooting guide–AHT-63 hydraulic test stand–Continued

Trouble	Probable cause	Possible remedy
Hydraulic pump fails to compensate	Compensator control valve improperly adjusted.	Adjust compensator control valve to proper setting.
	Compensator control valve inoperative.	Replace compensator control valve.
Test Stand fails to deliver sufficient pressure.	Malfunction of high pressure relief valve and/or incorrect setting	Check high pressure relief valve setting. Replace defective valve.
	Bypass valve open or leaking.	Close bypass valve. Replace leaking valve.
System pressure too high	High pressure relief valve improperly adjusted.	Adjust high pressure relief valve to proper setting for specified aircraft.
	High pressure relief valve inoperative.	Replace defective high pressure relief valve.
	Compensator control valve set too high.	Adjust setting of compensator control valve.
Test Stand shuts down automatically during operation	Low boost pressure switch S8 has acted to shut off motor due to a fluid supply pressure drop of below 35 psi.	Check fluid supply. Repair or replace defective low boost pump.
	Overload on motor.	Reset overload relay

which supports the element under differential pressures up to 3,000 psi. The woven wires form minute pores that prevent passage of particles larger than the filter rating. Filters of this type are usually rated 15-, 25-micron, or larger. As hydraulic fluid flows through the filter element, oversize particles which become trapped in the element plug some of the pores and cause an increased flow through the remaining open pores. This partial restriction or reduction in the effective area of filtration produces a differential pressure across the filter element. If plugging of the pores continues, this differential pressure will wedge the contaminants firmly into the filtering media structure.

The cleaning problem becomes even more severe when the aircraft hydraulic system is subjected to extremely high operating temperatures. Heat causes some hydraulic fluid decomposition and results in varnish deposits or accumulations. Under these conditions, the buildup of particle contaminants is accompanied by a simultaneous buildup of fluid decomposition matter. This combination of particle contaminants and residual varnish presents a difficult cleaning problem. Additional coverage on the types of filters and filter repair procedures is provided later in this chapter.

The Aero Material Department of the Naval Air Development Center created a two-stage cleaning process that is considered adequate. The first stage uses a varnish remover and the second a chlorinated solvent. This two-stage method of cleaning combines a chemical and

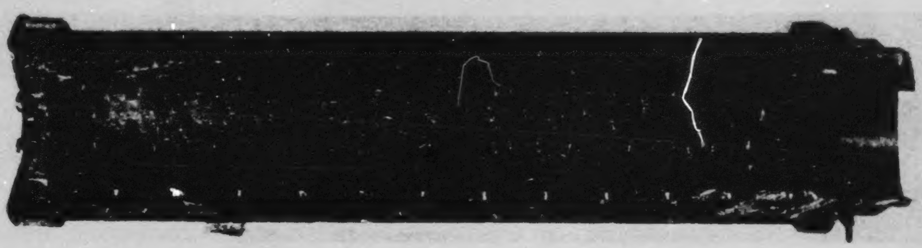

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Figure 11-45.—Aircraft hydraulic filter element cutaway—15 micron.

ultrasonic attack on the contaminants trapped within the filter element. The ultrasonic cleaning concept demands an ultrasonic presoak or boiling tank, an ultrasonic vapor degreaser for thorough cleaning of the filter element, and a testing tank to verify the effectiveness of the cleaning process and to ensure that the element meets the minimum test criteria established for that particular element.

The Model 2300, Ultrasonic Aircraft Filter Cleaner and the Model N-470, Ultrasonic Cleaning and Testing Machine, are discussed in the *AMH 3 & 2 Rate Training Manual,* NAVEDTRA 10310-B. Coverage includes a complete description and basic operating procedures. Familiarity with this material is presumed in discussing the following cleaning procedures.

Single units or combinations of units that will accomplish the same degree of cleanliness and meet the standards required in NAVAIR 01-1A-17 may be used as alternate cleaning and testing equipment.

Inspection

Filters removed from an aircraft or ground support equipment for ultrasonic cleaning and testing should be placed in suitable racks or packaged individually for transportation to the inspection and cleaning area. The element should be inspected visually for dents, holes, broken wires, sharp corners, or other damage that would be cause for rejection of the filter prior to cleaning.

CLEANING PROCEDURE.—Shorebased cleaning procedures consist of utilizing the ultrasonic cleaner and tester to accomplish the following steps:

1. The first step consists of mounting the filters in a specially designed mount rack such as the one illustrated in figure 11-46. This rack prevents contaminants from entering the element opening and staggers the element's arrangement to minimize any shadow effect from the ultrasonic energy during the cleaning process. The small knob located atop the rack handle rotates the filters a full 360 degrees on their longitudinal axis through a chain and sprocket mechanism. The rack mounted elements are placed in a boiling solution of 1, 1, 1 trichloroethane for a minimum of 5 minutes to a maximum of 20 minutes to remove some of the gross contaminants including hydraulic fluid. The element is then removed from the boiling tank and allowed to drain.
2. Next, the mounted element is transferred to the presoak tank containing cleaning compound, Military Specification, MIL-C-6864-C, and equipped with ultrasonic radiation. The element is ultrasonically cleaned/presoaked for 20 minutes with the element being rotated 90 degrees every 5 minutes to ensure that all surfaces are subjected to the ultrasonic beams.

Remove the filter element from the presoak, allow it to drain, then rinse in 1, 1, 1 trichloroethane. Agitate the filter element in the rinse tank fluid to remove as much particle contamination and cleaning compound as possible. This rinse is optional, its purpose being to reduce the carryover of

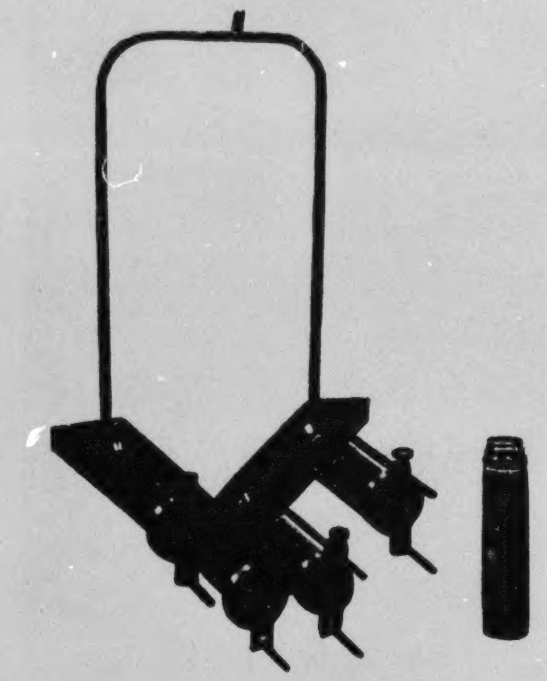

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Figure 11-46.—Filter element cleaning rack.

contaminants into the second boiling. When the ultrasonic radiation of the presoak cleaning compound is taking place, the fluid will be heated. The ultrasonic treatment should be terminated when the temperature of the cleaning compound rises to a point 15°F below the boiling point.

3. Next, the element is boiled a second time in the same manner as the first boil was conducted.

4. Following the second boil the filter element is transferred to the ultrasonic cleaning bath for the final cleanup of contaminants. This bath contains 1, 1, 1 tricholoroethane. The ultrasonic cycle is maintained for 20 minutes with the element being rotated 90 degrees every 5 minutes as in the presoak tank. The temperature of the clean tank should be monitored so that the temperature of the bath does not exceed 145°F. Trichloroethane should be continuously overflowing from the condensate tank into the ultrasonic cleaning tank and the boil tank so that contaminants are removed from the top of the clean tank solution. The flow of solution should be one-half gallon per minute so that the filtration/recirculation pump draws contaminants from the bottom of the boil tank. To prevent redepositing of particles on the clean element, keep the ultrasonic generator operating until the element is removed from the clean tank.

5. The filter is then removed from the cleaning rack and prepared for the flow test and bubble point test. The filter should be protected from contamination both before and after cleaning by placing it in a clean polyethylene plastic bag.

If the ultrasonic energy is lost in the cleaning tank and repairs cannot be made, an alternate cleaning procedure is provided which is more time consuming because of the longer soak times, etc. These alternate procedures are detailed in NAVAIR 01-1A-17, *Aircraft Hydraulics Manual.*

Testing

All elements after being thoroughly cleaned must undergo two tests–a bubble point test and a flow test. The bubble test is used to determine that the largest pore openings of the filter media do not exceed the allowable limits. Elements that are worn or damaged may have pore openings larger than specified and therefore allow particles larger than the filter rating to pass through. The flow test is used to ascertain whether a clean, undamaged filter has been thoroughly cleaned or still has partially clogged pore openings.

In the bubble test, the element is mounted on the test tank holding fixture using the special adapter for that type filter. Figure 11-47 illustrates the test tank holding fixture. The mounted element is lowered into the test tank which contains decontaminated 1, 1, 1 trichloroethane. Decontamination of the 1, 1, 1 trichloroethane is automatically achieved on the N-470 ultrasonic cleaner and tester. If other units are used, they must be decontaminated by distillation and passage through a 3-micron filter

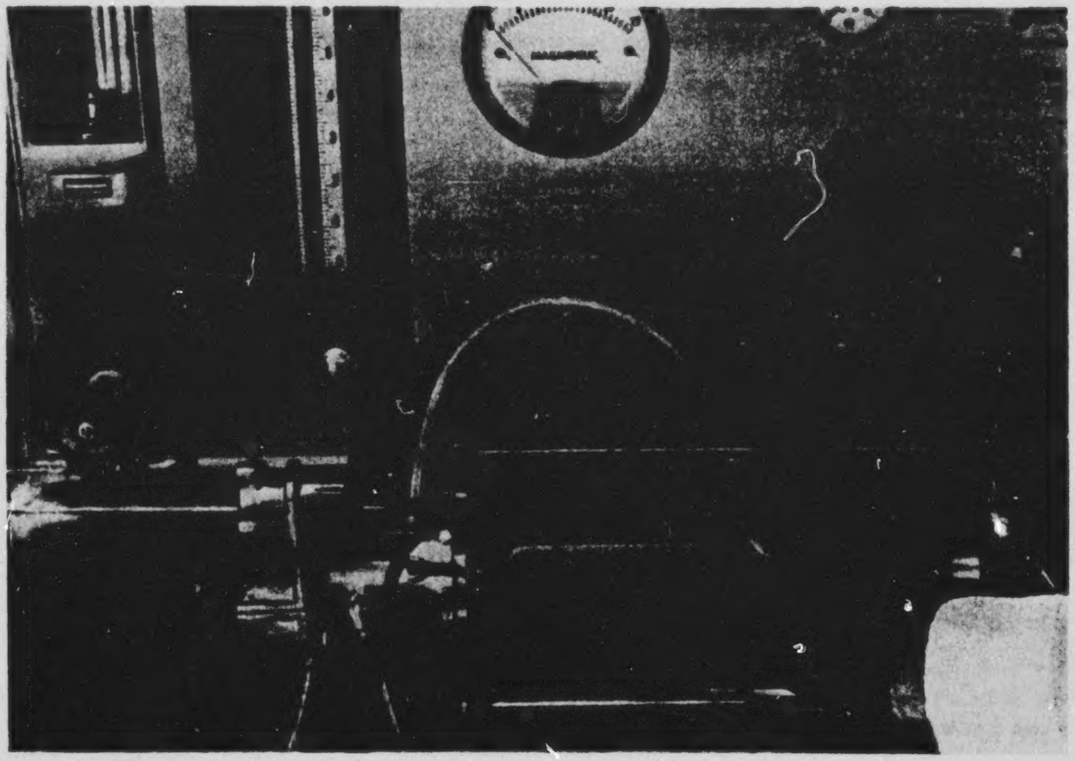

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Figure 11-47.—Test tank holding fixture.

(absolute). The test tank temperture should be maintained at 90°F, ±5°.

Test criteria for some specific aircraft filter elements is provided in NAVAIR 01-1A-17. If the element being tested is not listed and the test values are not marked on the filter element, the test criteria may be computed, using the procedures specified in the *Aircraft Hydraulics Manual.* A list of filter element criteria for the F-4 and A-6 is provided in table 11-15. The actual test is conducted according to the instructions provided for the particular type of tester and the specific filter element being tested. In general, the bubble test consists of the following steps:

1. Turn on the air supply and regulate the coarse air supply to approximately 8 psi on the air pressure gage.
2. The fine air regulator is fully opened to the left until the bubble point gage indicates the minimum value.
3. Next, the test selector control is turned to the BUBBLE TEST position, and the fine air regulator valve is turned to the right until the bubble point gage displays the value specified for the particular element being tested. In the test criteria established in table 11-15, the bubble point gage reading is listed in the right-hand column.
4. To help locate the source of any air bubbles, the element is slowly rotated by means of the holding handle on the holding fixture. The intermittent emission of bubbles may be disregarded because it is probably caused by the escape of air trapped between the accordian pleats on the outside of the element. A continuous stream of bubbles indicates the

Table 11-15.–Specific aircraft filter element test criteria

Aircraft	Filter element part number	Probe	Adapter	Flow %	Maximum pressure drop (inches water)	XWS-5551 Rev. A minimum bubble point (inches water)
F-4	21-10489	4	1	0.8	4.4	9.5
	AC900E-6	3	4	40	4.8	9.5
	21-10258	4	3	50	6.0	9.5
	AC900E-12	4	3	60	2.6	9.5
A-6	AC3255E-8	1	None	20	8.3	14.8
	AC3255E-12	1	None	50	9.3	14.8
	AC3255E-16	1	None	50	7.0	14.8

presence of an oversized pore opening, which must be repaired. Approved epoxy kits are available for this purpose.

5. When the bubble test is completed, the test selector is returned to the MANOMETER position.

To perform the flow test, the test selector handle is turned to the FLOW TEST position and the flow test pump is energized. The flow control valve is adjusted until the flowmeter indicates the specified percentage of flow for that particular element. The flow rate appears in the FLOW % column of table 11-15. The manometer displays the pressure drop across the element. If the drop exceeds the maximum allowable value, the element should be recleaned. When the test is completed, the flow pump is secured and the test selector is returned to the MANOMETER VENT position.

The number of attempts made to adequately clean a filter is left up to the judgment of the operator. Normally, a maximum of three attempts will be made in recleaning the filter so that it will pass the flow test. However, if after the third attempt the flow test indicates significant improvement, then additional cleaning may be accomplished as necessary. In such cases the duration of the cleaning period in the ultrasonic cleaning tank and/or the presoak tank may be increased. Monitor the temperature of fluid in the tanks if the cycle is extended.

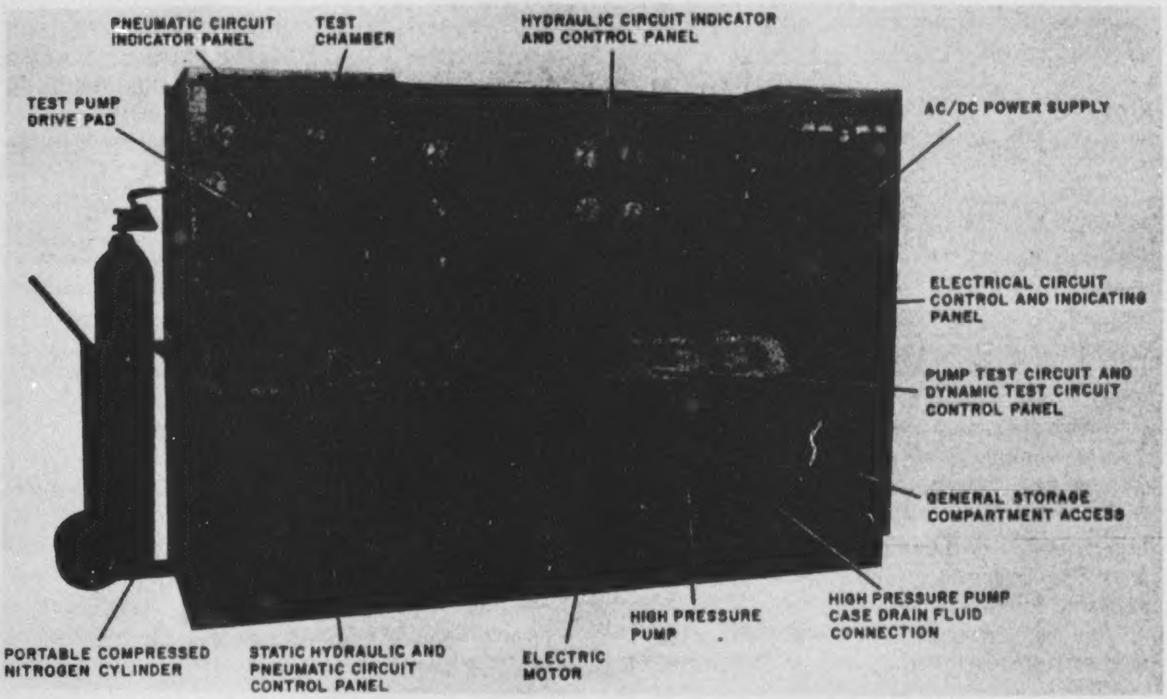
When elements do not pass the bubble test, reduce the air pressure to zero and then gradually increase the pressure until the first continuous stream of bubbles occurs. Repair any elements showing a bubble point of more than 3 inches H_2O on the Manometer. Discard those showing a bubble point of less than 3 inches H_2O. Areas to be repaired are marked with a red lead pencil at the time the element fails the test. During the bubble testing, do not touch the filtering surface of the element or allow it to touch the sides of the testing tank.

Packaging

Filters that have been cleaned and have successfully passed the bubble point test and the flow test are completely dried and sealed in the proper size clean, polethylene plastic bag. Each bagged filter is packed in an appropriate size fiberboard box, and the box is sealed and labeled to identify the filter element by part number.

Cleaning Precautions

The chemicals used in the filter cleaning process can be extremely harmful and must be handled with care. The cleaning compound used in the presoak tank contains phenols and chlorinated hydrocarbons and is flammable


PNEUMATIC CIRCUIT INDICATOR PANEL
TEST CHAMBER
HYDRAULIC CIRCUIT INDICATOR AND CONTROL PANEL
TEST PUMP DRIVE PAD
AC/DC POWER SUPPLY
ELECTRICAL CIRCUIT CONTROL AND INDICATING PANEL
PUMP TEST CIRCUIT AND DYNAMIC TEST CIRCUIT CONTROL PANEL
GENERAL STORAGE COMPARTMENT ACCESS
HIGH PRESSURE PUMP CASE DRAIN FLUID CONNECTION
HIGH PRESSURE PUMP
PORTABLE COMPRESSED NITROGEN CYLINDER
STATIC HYDRAULIC AND PNEUMATIC CIRCUIT CONTROL PANEL
ELECTRIC MOTOR

216.47

Figure 11-48.—Hydraulic and pneumatic test stand—HCT-10 (front view).

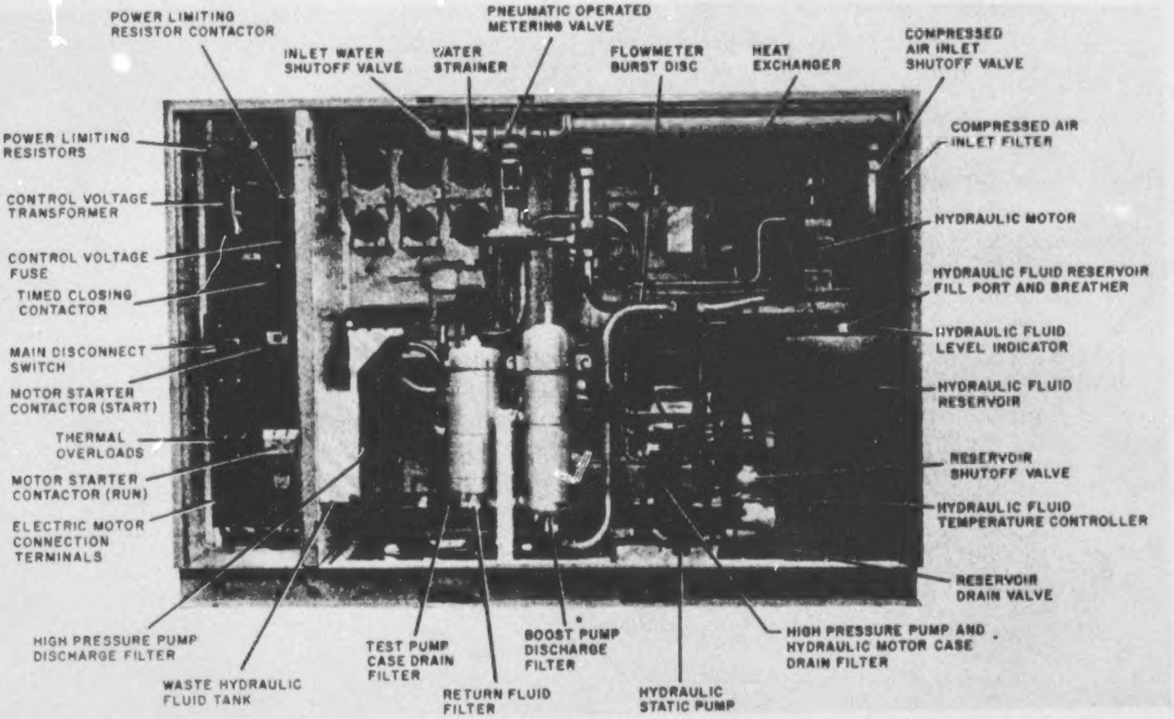
beyond its boiling point. Skin contact or breathing of the vapors can be harmful to the exposed skin or lungs of the operator. The cleaning compound should be used only in well-ventilated places with adequate fume withdrawal provisions. Do not heat the cleaning compound and keep tanks covered when not in actual use. Wear chemical safety gloves, aprons, and face shield when working with this compound. Avoid breathing the vapors; if skin contact does occur, immediately rinse it off with large amounts of fresh water followed by an alcohol rinse. Do not smoke or allow open heating processes to be conducted in the vicinity of the cleaning and testing equipment.

For effective cleaning, the tanks should not be touched when the ultrasonic generators are operating. The racks and baskets holding the elements being cleaned should touch the tanks only at the points provided for that purpose. DO NOT reach in the tank solutions when the ultrasonic generators are ON. The condition of the solutions in the various tanks must be maintained to provide effective cleaning.

The size and expense of the N-470 ultrasonic cleaner and tester and the trend to increased use of the disposable type micron filters make it rather impractical to procure them for shipboard use. Alternate methods similar to those discussed in the previous paragraphs have been adopted for shipboard filter cleaning. Personnel aboard ship who are responsible for filter element cleaning should consult the specific instructions provided in NAVAIR 01-1A-17.

HYDRAULIC AND PNEUMATIC COMPONENT TEST STANDS

The portable hydraulic test stand is the primary equipment utilized by the hydraulics


POWER LIMITING RESISTOR CONTACTOR
PNEUMATIC OPERATED METERING VALVE
INLET WATER SHUTOFF VALVE
WATER STRAINER
FLOWMETER BURST DISC
HEAT EXCHANGER
COMPRESSED AIR INLET SHUTOFF VALVE
COMPRESSED AIR INLET FILTER
POWER LIMITING RESISTORS
CONTROL VOLTAGE TRANSFORMER
CONTROL VOLTAGE FUSE
TIMED CLOSING CONTACTOR
MAIN DISCONNECT SWITCH
MOTOR STARTER CONTACTOR (START)
THERMAL OVERLOADS
MOTOR STARTER CONTACTOR (RUN)
ELECTRIC MOTOR CONNECTION TERMINALS
HYDRAULIC MOTOR
HYDRAULIC FLUID RESERVOIR FILL PORT AND BREATHER
HYDRAULIC FLUID LEVEL INDICATOR
HYDRAULIC FLUID RESERVOIR
RESERVOIR SHUTOFF VALVE
HYDRAULIC FLUID TEMPERATURE CONTROLLER
RESERVOIR DRAIN VALVE
HIGH PRESSURE PUMP AND HYDRAULIC MOTOR CASE DRAIN FILTER
HIGH PRESSURE PUMP DISCHARGE FILTER
WASTE HYDRAULIC FLUID TANK
TEST PUMP CASE DRAIN FILTER
RETURN FLUID FILTER
BOOST PUMP DISCHARGE FILTER
HYDRAULIC STATIC PUMP

216.48

Figure 11-49.—Hydraulic and pneumatic test stand—HCT-10 (rear view).

maintenanceman involved in organizational level maintenance. In the performance of his duties, he applies external hydraulic and electrical power and utilizes the aircraft as a test bench when performing operational and functional checks of systems.

The hydraulic man at the intermediate level of maintenance is more concerned with component repair and rework and must have some means to verify the proper operation of components that have been subjected to cure date seal replacement and miscellaneous parts replacement or repair. This equipment must duplicate as nearly as possible the conditions under which the part must function as though it were actually installed on the aircraft.

The Intermediate Component Repair section of the Maintenance Instructions Manuals and/or 03 Manuals provides a graphic illustration of the test stand arrangement required to verify proper operation of each component that may be repaired at the intermediate level of maintenance.

The stationary hydraulic test stands discussed in chapter 10 of the *AMH 3 & 2 Rate Training Manual,* NAVEDTRA 10310-B, are representative of those utilized by most intermediate maintenance activities. The Model HCT-10, Hydraulic and Pneumatic Test Stand, illustrated in figures 11-48 and 11-49, is one of the latest models in use. It is used to bench test aircraft hydraulic and pneumatic components such as engine-driven hydraulic pumps, electrohydraulic flight control assemblies, single- and double-acting hydraulic actuating cylinders, pneumatic and hydraulic relief valves, accumulators, and almost all other components.

The HCT-10 test stand is a much more sophisticated model than those of the past. It offers complete facilities for testing the electrical as well as the hydraulic and/or pneumatic portion of various components.

The hydraulic system of the HCT-10 is composed of three circuits–the dynamic test circuit, the static test circuit, and the pump test circuit. Electrical power required for testing electrohydraulic components is supplied by an external power source and controlled by the electrical system controls located on the right-hand control panel. The nitrogen cylinder provides a supply of nitrogen through test stand controls for static pneumatic testing. The gas can be directed through an air-operated gas booster when static pressure above that which is directly available from the cylinder is required.

Coverage of the HCT-10 in *AMH 3 & 2* includes a general description of the overall test stand including gages, controls, external power requirements, and basic operating procedures. It is impractical to attempt to cover the operating and testing procedures in depth. Complete operating instructions are supplied with each test stand and should be carefully studied prior to operating the equipment. All personnel assigned to operate the equipment should become thoroughly familiar with the Operation, Servicing, and Overhaul Instructions for the particular model they will be using. Like most aircraft support equipment, the HCT-10 is expensive, and operation by an inexperienced and unqualified operator can result in test stand and component damage and personnel injury.

APPENDIX I

THE METRIC SYSTEM

The metric system was developed by French scientists in 1790 and was specifically designed to be an easily used system of weights and measures to benefit science, industry, and commerce. The metric system is calculated entirely in powers of 10, so one need not work with the various mathematical bases used with the English system, such as 12 inches to a foot, 3 feet to a yard, and 5280 feet to a mile.

The system is based on the "meter" which is one ten-millionth of the distance from the Equator to the North Pole. It is possible to develop worldwide standards from this base of measurement. The metric system of weights is based on the gram, which is the weight of a specific quantity of water.

Soon after the system was developed scientists over the world adopted it and were able to deal with the mathematics of their experiments more easily. The data and particulars of their work could be understood by other scientists anywhere in the world. During the early 19th century many European nations adopted the new system for engineering and commerce. It was possible for these countries to trade manufactured goods with one another without worrying whether it would be possible to repair machinery from another country without also buying special wrenches and measuring tools. Countries could buy and sell machine tools and other sophisticated and precision machinery without troublesome modifications or alterations. It was much easier to teach the metric system, since meters can be changed to kilometers or centimeters with the movement of a decimal point. which is roughly like being able to convert yards to miles or inches by adding zeros and a decimal instead of dividing by 1760 or multiplying by 36.

With the exception of the United States, all the industrialized nations of the world have adopted the metric system. Even England and Canada are changing from their traditional systems of measure, and the metric system will be almost universal by 1980.

Although the metric system has not been officially legislated by the Congress, the metric system is becoming more prominent in this country. Most automobile mechanics own some metric wrenches to work on foreign cars or foreign components in American cars. Almost all photographic equipment is built to metric standards. Chemicals and drugs are usually sold in metric quantities, and "calorie counters" are using a metric unit of thermal energy.

Because we are allied with countries who use the metric system, much of our military information is in metric terms. Military maps use meters and kilometers instead of miles, and many weapons are in metric sizes, such as 7.62 mm, 20 mm, 40 mm, 75 mm, and 155 mm. Interchange of military equipment has caused a mixture of metric and English measure equipment since World War I when the army adopted the French 75 mm field gun, and World War II when the Navy procured the Swedish 40 mm Bofors and the Swiss 20 mm Oerlikon heavy machine guns.

It is inevitable that the United States will officially adopt the metric system. Exactly when this happens and how rapidly the changeover will depend on economics, since the expense of retooling our industry and commerce to new measurements will be very great. The cost of conversion will be offset by increased earnings from selling machinery and products overseas. Another benefit is that scientists use the metric system, but their calculations now have to be translated into English measure to be used by industry. With adoption of the metric system ideas can go directly from the drawing board to the assembly line.

The Navy will be using the metric system more during the next few years. Although you will find it easier to solve problems using this system, at first you will find it difficult to visualize or to estimate quantities in unfamiliar units of measure.

Fortunately, many metric units can be related to equivalent units in the English system.

The meter which is the basic unit is approximately one-tenth longer than a yard.

The basic unit of volume, the liter, is approximately one quart. The gram is the weight of a cubic centimeter, or milliliter, of pure water and is the basic unit of weight. As a common weight though, the kilogram, or kilo, which equals the weight of a liter of water, weighs 2.2 pounds. The cubic centimeter (cc) is used where we would use the square inch, and where we measure by the fluid ounce, the metric system employs the milliliter (ml). For power measure the metric system uses the kilowatt (kW), which is approximately 1.3 horsepower.

In terms of distance, a land mile is eight-fifths of a kilometer and a nautical mile is 1.852 kilometers, or nearly 2 kilometers.

A basic metric expression of pressure is the kilogram per square centimeter, which is 14.2 psi, nearly 1 atmosphere of pressure.

When working on foreign machinery, you may notice that your half-inch, three-quarter inch, and one-inch wrenches will fit many of the bolts. These sizes correspond to 13 mm, 19 mm, and 26 mm respectively in the metric system, and are very popular because they are interchangeable. The 13/16-inch spark plug wrench, which is standard in this country, is intended to fit a 20 mm nut.

The basic quantities of the metric system are multiplied or divided by powers of 10 to give other workable values. We cannot easily measure machine parts in terms of a meter, so the millimeter, or one-thousandth of a meter is used. For very fine measure the micron, also called the micrometer, can be used. It is one-millionth part of a meter, or one-thousandth of a millimeter. For small weights the milligram, one-thousandth of a gram is used. All of these multiples are expressed with standard prefixes taken from Latin:

micro = 1/1,000,000
milli = 1/1,000
centi = 1/100
*deci = 1/10
*deca = 10
*hecto = 100
kilo = 1,000
*myria = 10,000
mega = 1,000,000

* Rarely used

Over the next few years the metric system will become more used by the Navy as well as by the civilian world. You will find it easy to work with once you have mastered the basic terms. It will be difficult to translate values from our present system to the metric system, but this operation will become unnecessary once the new measurements are totally adopted.

Tables of equivalent English measure and metric equivalents are essential when you work simultaneously with both systems. The table which follows shows the equivalent measures of the two systems. The columns on the left have the equivalent values which are accurate enough for most work, and on the right are the multiples used to convert the values with a high degree of accuracy.

ENGLISH AND METRIC SYSTEM UNITS OF MEASUREMENT

COMMON EQUIVALENTS AND CONVERSIONS

Approximate Common Equivalents		Conversions Accurate to Parts Per Million (units stated in abbreviated form)	
		Number X Factor	
1 inch	= 25 millimeters	in X 25.4*	= mm
1 foot	= 0.3 meter	ft X 0.3048*	= m
1 yard	= 0.9 meter	yd X 0.9144*	= m
1 mile†	= 1.6 kilometers	mi X 1.60934	= km
1 square inch	= 6.5 square centimeters	in^2 X 6.4516*	= cm^2
1 square foot	= 0.09 square meter	ft^2 X 0.0929030	= m^2
1 square yard	= 0.8 square meter	yd^2 X 0.836127	= m^3
1 acre	= 0.4 hectare	acres X 0.404686	= ha
1 cubic inch	= 16 cubic centimeters	in^3 X 16.3871	= cm^3
1 cubic foot	= 0.03 cubic meter	ft^3 X 0.0283168	= m^3
1 cubic yard	= 0.8 cubic meter	yd^3 X 0.764555	= m^3
1 quart (lq.)	= 1 liter	qt (lq.) X 0.946353	= *l*
1 gallon	= 0.004 cubic meter	gal X 0.00378541	= m^3
1 ounce (avdp)	= 28 grams	oz (avdp) X 28.3495	= g
1 pound (avdp)	= 0.45 kilogram	lb (avdp) X 0.453592	= kg
1 horsepower	= 0.75 kilowatt	hp X 0.745700	= kW
1 pound per square inch	= 0.07 kilogram per square centimeter	psi X 0.0703224	= kg/cm^2
1 millimeter	= 0.04 inch	mm X 0.0393701	= in
1 meter	= 3.3 feet	m X 3.28084	= ft
1 meter	= 1.1 yards	m X 1.09361	= yd
1 kilometer	= 0.6 mile	km X 0.621371	= mi
1 square centimeter	= 0.16 square inch	cm^2 X 0.155000	= in^2
1 square meter	= 11 square feet	m^2 X 10.7639	= ft^2
1 square meter	= 1.2 square yards	m^2 X 1.19599	= yd^2
1 hectare	= 2.5 acres	ha X 2.47105	= acres
1 cubic centimeter	= 0.06 cubic inch	cm^3 X 0.0610237	= in^3
1 cubic meter	= 35 cubic feet	m^3 X 35.3147	= ft^3
1 cubic meter	= 1.3 cubic yards	m^3 X 1.30795	= yd^3
1 liter	= 1 quart (lq.)	*l* X 1.05669	= qt (lq.)
1 cubic meter	= 250 gallons	m^3 X 264.172	= gal
1 gram	= 0.035 ounces (avdp)	g X 0.0352740	= oz (avdp)
1 kilogram	= 2.2 pounds (avdp)	kg X 2.20462	= lb (avdp)
1 kilowatt	= 1.3 horsepower	kW X 1.34102	= hp
1 kilogram per square centimeter	= 14.2 pounds per square inch	kg/cm^2 X 14.223226	= psi

†nautical mile = 1.852 kilometers

* exact

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QUALIFICATIONS FOR ADVANCEMENT

This appendix provides you with a list of the minimum qualifications for advancement to Aviation Structural Mechanic H First and Chief. The official source of this list is the Manual of Qualifications for Advancement, NAVPERS 18068-C, 1971. The assignment numbers given opposite the qualifications refer to the assignments in the NRCC, Aviation Structural Mechanic H 1 & C, NAVEDTRA 10313-C. Each course assignment contains information related to a practical or knowledge factor, as shown.

AVIATION STRUCTURAL MECHANIC H (Hydraulics) - AMH

Aviation Structural Mechanics (H) maintain hydraulic systems including main and auxiliary power systems and unit actuating subsystems, landing gear excluding wheels and tires, brakes, related pneumatic systems including reservoir pressurization and emergency actuating systems and associated pumps, valves, regulators, actuating cylinders, lines and fittings; service pressure accumulators, emergency air bottles, oleo struts, reservoirs, and master brake cylinders; inspect, remove, and replace components of hydraulic systems; bleed hydraulic systems; adjust brakes and replace linings and pucks; replace gaskets, packing, and wipers in hydraulic components; and perform daily, preflight, postflight, and other periodic aircraft inspections.

QUALIFICATIONS FOR ADVANCEMENT		Required for Advancement to AMH	Covered in Assignment
A.	SAFETY		
1.00	Practical Factors		
.80	Inspect work areas, tools, and equipment to detect potentially hazardous and unsafe conditions and take appropriate corrective action	E-7	1, 2
.81	Organize and administer a program of safety instruction applicable to aviation structural mechanic equipment and facilities.	E-7	1, 2
2.00	Knowledge Factors		
	None		

QUALIFICATIONS FOR ADVANCEMENT		Required for Advancement to AMH	Covered in Assignment
B.	AIRCRAFT INSPECTION AND MAINTENANCE		
1.00	Practical Factors		
.60	Supervise and direct aircraft inspections . .	E-6	OPNAVINST 4790.2 (Series)
.61	Maintain work center registers and prepare local reports required by the Naval Aircraft Maintenance Program	E-6	1, 2
.62	Inspect installation and evaluate operation of repaired or newly installed parts and components.	E-6	1, 2, 4, 5, 6, 7, 8
.63	Interpret and verify input source documents to the 3-M System	E-6	1, 2, OPNAVINST 4790.2 (Series)
.80	Analyze reports of discrepancies and malfunctions and determine corrective action . .	E-7	1, 2
.81	Read and interpret daily and monthly MDR and MHA reports	E-7	OPNAVINST 4790.2 (Series)
2.00	Knowledge Factors		
.60	Procedures for inventory of aircraft.	E-6	OPNAVINST 4790.2 (Series)
.80	Procedures for hoisting aircraft.	E-7	OPNAVINST 4790.2 (Series)
C.	AIRFRAME AND FLIGHT CONTROL RIGGING AND ALIGNMENT		
1.00	Practical Factors		
.60	Remove and install wings, wing panels, and stabilizers	E-6	7, 8
.80	Analyze malfunctions of flight control systems and determine corrective action . . .	E-7	7, 8
.81	Diagnose aircraft irregular flight characteristics and overstressing and determine corrective action	E-7	7, 8

QUALIFICATIONS FOR ADVANCEMENT	Required for Advancement to AMH	Covered in Assignment
C. AIRFRAME AND FLIGHT CONTROL RIGGING AND ALIGNMENT - Continued		
2.00 Knowledge Factors		
.60 Effects of misalignment of airframes and flight controls on aircraft flight characteristics.	E-6	7, 8
.61 Procedures for tracking rotor blades	E-6	7, 8
D. METALS		
1.00 Practical Factors		
.62 Perform and interpret magnetic particle inspections.	E-6	4
F. HYDRAULIC AND PNEUMATIC SYSTEMS		
1.00 Practical Factors		
.60 Rig and adjust control and actuating mechanisms and linkages.	E-6	5, 6, 7, 8
.80 Analyze aircraft hydraulic system malfunctions, isolate defective components, and determine corrective action. (NOTE: Personnel in the AMH Service Rating isolate troubles in electrically controlled hydraulic systems. Personnel in the AE rating repair and replace electrical components)	E-7	1, 2, 4, 5, 6, 7, 8
.81 Establish a program for prevention of externally induced hydraulic system contamination.	E-7	8
2.00 Knowledge Factors		
.60 Operation and interrelationships of components of hydraulic and pneumatic systems.	E-6	4, 5, 6, 7, 8
.80 Procedures for determining need, and methods for flushing hydraulic systems	E-7	8
G. LANDING GEAR		
1.00 Practical Factors		
.60 Rig and adjust nosewheel steering mechanisms	E-6	6, 7

QUALIFICATIONS FOR ADVANCEMENT		Required for Advancement to AMH -	Covered in Assignment
G.	LANDING GEAR - Continued		
1.00	Practical Factors - Continued		
.61	Supervise landing gear drop checks	E-6	6, 7
.62	Replace landing gear assemblies; disassemble landing gear struts and replace internal components.	E-6	6, 7
.81	Determine repair procedures for damaged landing gear	E-7	6, 7
2.00	Knowledge Factors		
.60	Procedures for checking landing gear alignment.	E-6	6, 7
K.	DRAWINGS, SCHEMATICS, AND BLUEPRINTS		
1.00	Practical Factors		
.60	Use schematic diagrams, drawings, and charts in troubleshooting and correcting material failures.	E-6	Blueprint Reading and Sketching, NP10077-C, 4, 5, 6, 7, 8
.80	Read and interpret drawings and blueprints	E-7	4, 5
2.00	Knowledge Factors		
	None in addition to those implied in the above Practical Factors.		
Z.	ADMINISTRATION		
1.00	Practical Factors		
.60	Use NavAir Publications Index and NavSup 2002, Section VIII to identify and order technical publications, directives, and manuals.	E-6	1, 2
.61	Maintain current shop files of applicable technical publications, directives, and manuals.	E-6	1, 2
.62	Identify and order aircraft parts, tools, equipment, and material; maintain inventory records.	E-6	1, 2, 3

QUALIFICATIONS FOR ADVANCEMENT	Required for Advancement to AMH	Covered in Assignment
Z. ADMINISTRATION - Continued		
1.00 Practical Factors - Continued		
.82 Interpret and apply Aircraft Changes, bulletins, and technical directives	E-7	1, 2, OPNAVINST 4790.2 (Series)
.83 Plan, organize, lay out, and supervise airframe work centers; schedule and assign workload	E-7	1, 2, 5, 6
.84 Supervise inspection procedures to ensure that applicable technical specifications and standards of workmanship are met	E-7	1, 2, OPNAVINST 4790.2 (Series)
.85 Prepare for advanced base or forward area operations by estimating aircraft spare parts and supplies, equipment, and manpower requirements	E-7	1, 2
2.00 Knowledge Factors		
.60 Organization and functions of material control	E-6	2, 3
.61 Types of information to be recorded in applicable section of the aircraft log book and Aeronautical Equipment Service Record	E-6	1, 2, OPNAVINST 4790.2 (Series)
.80 Standard organization and maintenance management procedures of organizational and intermediate maintenance activities	E-7	OPNAVINST 4790.2 (Series)
.81 Purpose and procedures for manhour accounting	E-7	OPNAVINST 4790.2 (Series)
.82 Procedures for preparing tool, equipment, and material evaluation reports	E-7	1, 2

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AVIATION STRUCTURAL MECHANIC H 1 & C

NAVEDTRA 10313-C

Prepared by the Naval Education and Training Program Development Center, Pensacola, Florida

Your NRCC contains a set of assignments and self-scoring answer sheets (packaged separately). The Rate Training Manual, Aviation Structural Mechanic H 1&C, NAVEDTRA 10313-C, is your textbook for the NRCC. If an errata sheet comes with the NRCC, make all indicated changes or corrections. Do not change or correct the textbook or assignments in any other way.

HOW TO COMPLETE THIS COURSE SUCCESSFULLY

Study the textbook pages given at the beginning of each assignment before trying to answer the items. Pay attention to tables and illustrations as they contain a lot of information. Making your own drawings can help you understand the subject matter. Also, read the learning objectives that precede the sets of items. The learning objectives and items are based on the subject matter or study material in the textbook. The objectives tell you what you should be able to do by studying assigned textual material and answering the items.

At this point you should be ready to answer the items in the assignment. Read each item carefully. Select the BEST ANSWER for each item, consulting your textbook when necessary. Be sure to select the BEST ANSWER from the subject matter in the textbook. You may discuss difficult points in the course with others. However, the answer you select must be your own. Use only the self-scoring answer sheet designated for your assignment. Follow the scoring directions given on the answer sheet itself and elsewhere in this course.

Your NRCC will be administered by your command or, in the case of small commands, by the Naval Education and Training Program Development Center. No matter who administers your course you can complete it successfully by earning grades that average 3.2 or higher. If you are on active duty, the average of your grades in all assignments must be at least 3.2. If you are NOT on active duty, the average of your grades in all assignments of each creditable unit must be at least 3.2. The unit breakdown of the course, if any, is shown later under Naval Reserve Retirement Credit.

WHEN YOUR COURSE IS ADMINISTERED BY LOCAL COMMAND

As soon as you have finished an assignment, submit the completed self-scoring answer sheet to the officer designated to administer it. He will check the accuracy of your score and discuss with you the items that you do not understand. You may wish to record your score on the assignment itself since the self-scoring answer sheet is not returned.

If you are completing this NRCC to become eligible to take the fleetwide advancement examination, follow a schedule that will enable you to complete all assignments in time. Your schedule should call for the completion of at least one assignment per month.

Although you complete the course successfully, the Naval Education and Training Program Development Center will not issue you a letter of satisfactory completion. Your command will make a note in your service record, giving you credit for your work.

WHEN YOUR COURSE IS ADMINISTERED BY THE NAVAL EDUCATION AND TRAINING PROGRAM DEVELOPMENT CENTER

After finishing an assignment, go on to the next. Retain each completed self-scoring answer sheet until you finish all the assignment in a unit (or in the course if it is not divided into units). Using the envelopes provided, mail your self-scored answer sheets to the Naval Education and Training Program Development Center where the scores will be verified and recorded. Make sure all blanks at the top of each answer sheet are filled in. Unless you furnish all the information required, it will be impossible to give you credit for your work. You may wish to record your scores on the assignments since the self-scoring answer sheets are not returned.

The Naval Education and Training Program Development Center will issue a letter of satisfactory completion to certify successful completion of the course (or a creditable unit of the course). To receive a course-completion letter, follow the directions given on the course-completion form in the back of this NRCC.

You may keep the textbook and assignments for this course. Return them only in the event you disenroll from the course or otherwise fail to complete the course. Directions for returning the textbook and assignments are given on the book-return form in the back of this NRCC.

PREPARING FOR YOUR ADVANCEMENT EXAMINATION

Your examination for advancement is based on the Manual of Qualifications for Advancement (NAVPERS 18068). The sources of questions in this examination are given in the Bibliography for Advancement Study (NAVEDTRA 10052). Since your NRCC and textbook are among the sources listed in this bibliography, be sure to study both in preparing to take your advancement examination. The qualifications for your rating may have changed since your course and textbook were printed, so refer to the latest editions of NAVPERS 18068 and NAVEDTRA 10052.

NAVAL RESERVE RETIREMENT CREDIT

This course is evaluated at 12 Naval Reserve retirement points.

These points are creditable to personnel eligible to receive them under current directives governing the retirement of Naval Reserve personnel. Credit cannot be given again for this course if the student has previously received credit for completing any other Aviation Structural Mechanic H 1&C, NRCC or ECC.

COURSE OBJECTIVE

The broad objective of this course is that as you progress through the course you will demonstrate an understanding of the AMH 1&C subject matter by correctly answering items based on: Aviation Structural Mechanic H rating; work center supervision and administration; aviation supply; corrosion control; nondestructive inspection of metals; power system maintenance; brake system maintenance; landing gear maintenance; flight control system maintenance; actuating system maintenance; and general hydraulic system maintenance.

While working on this nonresident career course, you may refer freely to the text. You may seek advice and instruction from others on problems arising in the course, but the solutions submitted must be the result of your own work and decisions. You are prohibited from referring to or copying the solutions of others, or giving completed solutions to anyone else taking the same course.

Naval nonresident career courses may include a variety of items -- multiple-choice, true-false, matching, etc. The items are not grouped by type; regardless of type, they are presented in the same general sequence as the textbook material upon which they are based. This presentation is designed to preserve continuity of thought, permitting step-by-step development of ideas. Some courses use many types of items, others only a few. The student can readily identify the type of each item (and the action required of him) through inspection of the samples given below.

MULTIPLE-CHOICE ITEMS

Each item contains several alternatives, one of which provides the best answer to the item. Select the best alternative and erase the appropriate box on the answer sheet.

SAMPLE

s-1. The first person to be appointed Secretary of Defense under the National Security Act of 1947 was
1. George Marshall
2. James Forrestal
3. Chester Nimitz
4. William Halsey

The erasure of a correct answer is indicated in this way on the answer sheet:

	1 T	2 F	3	4	
s-1	■	C	■	■	

TRUE-FALSE ITEMS

Determine if the statement is true or false. If any part of the statement is false the statement is to be considered false. Erase the appropriate box on the answer sheet as indicated below.

SAMPLE

s-2. Any naval officer is authorized to correspond officially with a bureau of the Navy Department without his commanding officer's endorsement.

The erasure of a correct answer is also indicated in this way on the answer sheet:

	1 T	2 F	3	4	
s-2	■	CC	■	■	

MATCHING ITEMS

Each set of items consists of two columns, each listing words, phrases or sentences. The task is to select the item in column B which is the best match for the item in column A that is being considered. Specific instructions are given with each set of items. Select the numbers identifying the answers and erase the appropriate boxes on the answer sheet.

SAMPLE

In items s-3 through s-6, match the name of the shipboard officer in column A by selecting from column B the name of the department in which the officer functions.

A. Officers	B. Departments
s-3. Damage Control Assistant	1. Operations Department
s-4. CIC Officer	2. Engineering Department
s-5. Assistant for Disbursing	3. Supply Department
s-6. Communications Officer	

The erasure of a correct answer is indicated in this way on the answer sheet:

	1 T	2 F	3	4	
s-3	■	C	■	■	
s-4	C	■	■	■	
s-5	■	■	C	■	
s-6	C	■	■	■	

How To Score Your Immediate Knowledge of Results (IKOR) Answer Sheets

	1 T	2 F	3	4	
1	■	C	6	■	1
2	C	9	■	9	2
3	■	■	C	■	
4	CC	12	■	■	1

Total the number of incorrect erasures (those that show page numbers) for each item and place in the blank space at the end of each item.

Sample only

Number of boxes erased incorrectly	0-2	3-7	8-
Your score	4.0	3.9	3.8

Now TOTAL the column(s) of incorrect erasures and find your score in the Table at the bottom of EACH answer sheet.

NOTICE: If, on erasing, a page number appears, review text (starting on that page) and erase again until "C", "CC", or "CCC" appears. For courses administered by the Center, the maximum number of points (or incorrect erasures) will be deducted from each item which does NOT have a "C", "CC", or "CCC" uncovered (i.e., 3 pts. for four choice items, 2 pts. for three choice items, and 1 pt. for T/F items).

Assignment 1

Aviation Structural Mechanic H Rating and Work Center Supervision and Administration

Text: Pages 1 - 37

In this course you will demonstrate that learning has taken place by correctly answering training items. The mere physical act of indicating a choice on an answer sheet is not in itself important; it is the mental achievement, in whatever form it may take, prior to the physical act that is important and toward which nonresident career course learning objectives are directed. The selection of the correct choice for a course training item indicates that you have fulfilled, at least in part, the stated objective(s).

The accomplishment of certain objectives, for example, a physical act such as drafting a memo, cannot readily be determined by means of objective type course items; however, you can demonstrate by means of answers to training items that you have acquired the requisite knowledge to perform the physical act. The accomplishment of certain other learning objectives, for example, the mental acts of comparing, recognizing, evaluating, choosing, selecting, etc., may be readily demonstrated in a course by indicating the correct answers to training items.

The comprehensive objective for this course has already been given. It states the purpose of the course in terms of what you will be able to do as you complete the course.

The detailed objectives in each assignment state what you should accomplish as you progress through the course. They may appear singly or in clusters of closely related objectives, as appropriate; they are followed by items which will enable you to indicate your accomplishment.

All objectives in this course are learning objectives and items are teaching items. They point out important things, they assist in learning, and they should enable you to do a better job for the Navy.

This self-study course is only one part of the total Navy training program; by its very nature it can take you only part of the way to a training goal. Practical experience, schools, selected reading, and the desire to accomplish are also necessary to round out a fully meaningful training program.

Learning Objective: Indicate familiarity with the enlisted rating structure, possible duty assignments and responsibilities, and qualifications for advancement.

1-1. The general rating of Aviation Structural Mechanic applies to which of the following pay grades?
1. E-2 through E-9
2. E-4 through E-9
3. E-6 through E-8
4. E-8 only

1-2. An AMH1 or AMHC assigned to a Naval Air Maintenance Training Detachment will most likely hold a billet of
1. instructor
2. item writer
3. technical writer
4. research specialist in aircraft structures

1-3. If an AMH is assigned to instructor duty with a Naval Air Maintenance Training Detachment, he is first sent for instruction to
1. an aviation familiarization school
2. the class B AMH school
3. a factory school
4. the maintenance training group headquarters

1-4. In addition to being an accomplished military leader and a competent mechanic, an AMH1 must also meet which of these qualifications?
1. Instructor
2. Inspector
3. Supervisor
4. All of the above

1-5. The leadership qualities required of a senior PO can be acquired by
1. understanding leadership principles
2. studying leadership material
3. following the Naval Leadership Program
4. hard work and application of leadership principles

1-6. Which of these data should you pass on to personnel assigned to you concerning advancement?
1. Eligibility for advancement amounts to actual promotion once all training requirements are met
2. A good training record and high written examination scores are sufficient to ensure advancement
3. Advancement is automatic if satisfactory training progress is made
4. Promotion quotas, written examination scores, length of service, and performance marks all affect advancement

1-7. The publication which gives the minimum requirements for advancement is the
1. Naval Aeronautic Publications Index, NAVAIR 00-500
2. Bibliography for Advancement Study, NAVEDTRA 10052 (Series)
3. Manual of Qualifications for Advancement, NAVPERS 18068 (Series)
4. List of Training Manuals and Correspondence Courses, NAVEDTRA 10061 (Series)

1-8. Which of the following statements regarding the "Quals" Manual is correct?
1. It is issued every two years by the Bureau of Naval Personnel
2. It covers only the professional requirements for advancement
3. It lists qualifications for general ratings but not for service ratings
4. It covers both military and professional requirements for advancement in all rates and ratings

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Learning Objective: Indicate familiarity with the types, issuance, contents, numbering, and uses of publications and records required for advancement.

1-9. Which of the following actions should an AMH take when he is transferred?
1. Request a statement concerning his qualifications from the activity he is leaving
2. Secure his NAVEDTRA 1414/1(AM) and take it to his new commanding officer
3. Inform his new division chief that he has completed his practical factors
4. Ensure that his NAVEDTRA 1414/1(AM) is up to date and is in his service record

1-10. A NAVEDTRA 1414/1(AM) is used to record satisfactory performance of the practical factors by each man in pay grades
1. E-1 through E-9
2. E-2 through E-8
3. E-4 through E-8
4. E-4 through E-9

1-11. Which of the following statements is most inclusive regarding material which should be studied by an AMH who is preparing for the Navy-wide advancement examination?
1. The mandatory and recommended manuals are listed in Bibliography for Advancement Study, NAVEDTRA 10052 (Series)
2. The subjects covered in the "Quals" Manual are listed under practical factors
3. The mandatory manuals are listed in Bibliography for Advancement Study, NAVEDTRA 10052 (Series)
4. The professional mechanical aspects of the rating and those relating to military requirements are listed in several publications

1-12. How often and by what office is the publication, Bibliography for Advancement Study, NAVEDTRA 10052 (Series), issued in revised form?
1. Annually by the Chief of Naval Operations
2. Annually by the Naval Education and Training Support Command
3. Semiannually by the Bureau of Naval Personnel
4. Semiannually by the Chief of Naval Operations

1-13. Which of the following Rate Training Manuals is a rating manual?
1. Tools and Their Uses, NAVEDTRA 10085-B
2. Fluid Power, NAVEDTRA 16193-B
3. Blueprint Reading and Sketching, NAVEDTRA 10077-C
4. Aviation Structural Mechanic H 1 & C, NAVEDTRA 10313-C

1-14. The basic purpose of a Rate Training Manual is to
1. aid personnel to advance in rating
2. offer advanced study to graduates of Navy schools
3. teach specific equipment to personnel in specific ratings
4. cover the professional and military aspects of specific rates

1-15. Which of these steps is the first you should take in studying a Rate Training Manual?
1. Read the chapter headings
2. Outline the entire manual
3. Familiarize yourself with the entire manual
4. Prepare a list of questions to be answered as study progresses

1-16. The reason for including suggestions 4 and 7 in the list of study suggestions given in your textbook is that by following them you
1. are able to peg each subject to an individual qualification as given in the "Quals" Manual
2. familiarize yourself with the aims and contents of the manual and relate the subject area to your past experiences, thereby creating an excellent learning situation
3. write an outline of the manual which will be a valuable reference for future study
4. are able to separate the military qualifications from the professional qualifications in the textbook

1-17. The use of Nonresident Career Courses is encouraged for which of these reasons?
1. An idea of how much you have learned from a training manual can be obtained by taking the Nonresident Career Course
2. These courses assist you in mastering training manual information
3. Mandatory Rate Training Manuals can be completed by passing the Nonresident Career Course
4. All of the above reasons

Learning Objective: Recognize means of developing leadership qualities and duties relating to the training of others.

1-18. An important ability that must be developed as you advance is your ability to
1. impress others with your job knowledge
2. read technical material
3. write detailed, complete instructions concerning work procedures
4. speak and write in a manner understandable to others

1-19. As a senior petty officer, your authority and that of all officers rests upon the
1. position occupied
2. leadership qualities exhibited
3. degree of your specialized knowledge and skill
4. authority conferred by the commanding officer

1-20. A well-planned training program using NAVEDTRA 1414/1(AM) as a curriculum guide should be conducted so that each student will be
1. interested in the program
2. given an opportunity to lecture about his particular job
3. qualified as an instructor by the end of the training period
4. thoroughly qualified for the next higher rate by the time he is eligible for advancement

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Learning Objective: Recognize the elements within the trend of naval training.

1-21. What is the main purpose of self-paced instruction?
1. To keep up with the trend in naval training
2. To allow the student to study at his own pace
3. To reduce the cost of classroom instruction
4. To implement directives from higher headquarters

1-22. The purpose of "system-designed" instruction is to
1. teach the trainee to do a job
2. teach the trainee what he should do on his job
3. follow a specific course, such as defining the need, planning, developing, and evaluating the course
4. use programmed courses and audio/visual aids

1-23. Identify one of the elements of individualized training.
1. Programmed instruction courses
2. Reduced costs
3. Reduced training time
4. More effective classroom instruction

1-24. What feature of training prevailed in the past and will be eliminated?
1. On-board training
2. Class "A" schools
3. Multimedia packages
4. Overtraining

Learning Objective: Indicate paths of and requirements for advancement to Senior Chief, Master Chief, Warrant Officer, and Commissioned Officer.

1-25. What is the final requirement for promotion to E-8 and E-9?
1. Demonstrated qualities of leadership
2. Recommendation by the commanding officer
3. Selection by a regularly convened board
4. Successful completion of the Navy-wide examination

1-26. What is the lowest rate level in which enlisted personnel may apply for advancement to Warrant Officer (W-1)?
1. E-5
2. E-6
3. E-7
4. E-8

Learning Objective: Recognize principles of management and administration required of the supervising AMH.

1-27. The conscientious and intelligent application of which principle of management will ensure the most effective use of total resources?
1. Management by exception
2. Management by executive direction
3. Management by directing and controlling
4. Principle of planning and organizing

1-28. In order to be better prepared to handle the administrative affairs of his work center, the supervisor should become familiar with the contents of which volumes of the NAMP Manual?
1. 1, 2, 3, and 4
2. 1, 2, and 3 only
3. 1, 3, and 4 only
4. 2, 3, and 4 only

1-29. Which of the following is NOT one of the chief duties of the supervisor?
1. Policy making
2. Planning
3. Direction
4. Control

In items 1-30 through 1-32, select from column B the management function most closely associated with the statement in column A.

	A. Statements	B. Management Functions
1-30.	He sees that the work is started and knows what is going on at all times	1. Coordinating 2. Planning
		3. Directing
1-31.	He identifies each specific job to be done	4. Controlling
1-32.	He compares performance with plans	

1-33. Most problem areas that the supervisor encounters can be attributed to the lack of proper
1. control
2. planning
3. supervision
4. communications

Learning Objective: Recognize the needs for and techniques of work simplification.

In items 1-34 through 1-36, select from column B the management technique of work simplification that is most closely associated with the statement listed in column A.

A. Statements

1-34. It aids the supervisor in assigning men within their qualifications

1-35. It provides information useful in improving work methods and procedures

1-36. It is a study of the motions of individuals in performing their duties

B. Techniques

1. Work Count Analysis
2. Work Distribution Analysis
3. Layout Analysis
4. Motion Analysis

Learning Objective: Recognize factors to be considered and duties to be performed when planning and operating a work center.

1-37. Work center planning relative to the use of an already existing work center includes an evaluation of
1. equipment needed and functions to be performed
2. equipment on hand, equipment needed, functions to be performed, and space allocations
3. functions to be performed, equipment on hand, space allocations, and personnel requirements
4. space allocations, personnel requirements, and equipment on hand

1-38. What is the primary objective in arranging equipment in a work center?
1. Usefulness
2. Appearance
3. Centralized tool stowage
4. Utilization of all corner spaces

1-39. As a work center supervisor you have directed one of your men to develop a tool stowing system. The first thing that he should do is to
1. inventory the tools on hand
2. separate high- and low-usage tools
3. determine the amount of space that has been allocated for tool stowage
4. check the allowance lists and determine the quantity of tools to be stowed

1-40. Which of the following conditions should present the LEAST problem for the airframes work center supervisor when his squadron is operating aboard ship?
1. Limited work center space
2. Hazardous conditions on the flight deck
3. Hazardous conditions on the hangar deck
4. Reduced lighting during nighttime flight operations

1-41. If a part is delivered to the airframes work center and routine checking of identifying data indicates that it is not what was requisitioned, what action should you take?
1. Return the package to supply
2. Submit another requisition
3. Do both 1 and 2 above
4. Check to see if a suitable interchangeable item has been substituted

1-42. Which of the following statements relative to ground support equipment (GSE) is INCORRECT?
1. Utilization data must be provided by the reporting custodian on GSE in status code A
2. Items on subcustody must be returned to the supporting activity for all maintenance and upkeep
3. Supported activities are authorized to include GSE training in their work center's training syllabus
4. The supporting activity provides GSE training and licenses qualified operators

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Learning Objective: Indicate familiarity with technical directives, instructions, and notices used in an airframes work center.

1-43. Aircraft maintenance activities are furnished technical data necessary for the operation and maintenance of weapon systems and related equipment by
1. NAVAIRSYSCOMREPLANT
2. NAVAIREWORKFAC
3. NAVAIRSYSCOM
4. NATSF

1-44. Technical data available to fleet and repair activities fall into what major categories?
1. Technical manuals, technical directives, and engineering drawings and associated data
2. Instructions, notices, and technical directives
3. Instructions, changes, and bulletins
4. Technical manuals, technical directives, and technical instructions

1-45. Which of the following is used to disseminate technical instructions that cannot be satisfactorily disseminated by a revision or change to a technical manual?
1. Technical Directive
2. Technical Notice
3. Technical Order
4. Technical Note

1-46. Which of the following letter-type technical directives is most likely to be superseded by another type of technical directive?
1. A-5 Interim Airframe Bulletin No. 111
2. A-4 Interim Accessory Change No. 14
3. A-4 Accessory Bulletin No. 14
4. Either 1 or 3 above

In items 1-47 through 1-49, select from column B the definition of the letter-type technical directive listed in column A.

	A. Directives	B. Definitions
1-47.	Interim Change	1. A minor change to an original directive
1-48.	Airframe Change	2. A message directing a change regarding aircraft safety prior to the issuance of a formal directive
1-49.	Amendment	3. A complete reissue of a current directive
		4. A directive listing modification procedures for a change in the configuration of an aircraft

1-50. Which type of directive is identified as a completely new edition of an existing technical directive?
1. Amendment
2. Reissue
3. Revision
4. Change

In items 1-51 through 1-54, select from column B the Airframe Change action category applicable to the descriptive phrase listed in column A.

	A. Descriptive Phrases	B. Change Actions
1-51.	Usually grounds the aircraft until the remedial action is taken	1. Routine action
1-52.	Can be identified by a border of red diagonals around the cover page	2. Immediate action
1-53.	Relates to a condition that could result in injury to personnel or destruction of property, but is tolerable within a narrow time limit	3. Urgent action
1-54.	Is least likely to place an operational restriction on the aircraft	

1-55. What section of a technical directive will indicate the level of maintenance required to incorporate or accomplish the TD?
1. Application
2. Compliance
3. Enclosures
4. Subject

1-56. Relative to an Airframe Change, which of the following statements is correct?
1. It may or may not contain information which sets forth the reasons for the change
2. The supply data does not specify the required parts, kits, materials, and special tools necessary to make the change
3. If incorporation of the change results in a change in weight and balance, the effect is included in the change
4. Instructions concerning the steps that should be taken when actually making the change are not part of the change

1-57. Which of the following statements about the Rapid Action Change (RAC) System is INCORRECT?
1. It supplements the Normal Change System
2. It replaces the Interim Manual Change System
3. It provides for all changes to be disseminated within 15 days after problem resolution
4. It provides for urgently required technical information to be disseminated via naval message

1-58. Which of the following statements concerning Instructions and Notices is INCORRECT?
1. Instructions have continuing reference value
2. Instructions remain in effect until cancelled or superseded
3. Notices may never have an effective time period of more than one year
4. Notices have an effective time period of 6 months only

1-59. Which grouping includes the most information that may be obtained from the letters and numbers that follow the originator of an Instruction?
1. Originator, cancellation date, and subject matter series
2. Security classification, pamphlet-type publication, and subject matter series
3. Subject matter series, number of revisions, and cancellation date
4. Subject matter series, number of revisions, and security classification

1-60. Which of the following statements relative to Instructions and/or Notices is CORRECT?
1. Instructions must be filed by subject classification number and Notices by consecutive number
2. The subject classification group number of the Instruction that is most applicable to the work done in an airframes work center is 3000
3. A command's listing of its current Instructions and Notices is published semiannually in the form of a 5215 directive
4. Usually a pen-and-ink change to an Instruction is classified as a major change

Assignment 2

Work Center Supervision and Aviation Supply

Text: Pages 37-83

Learning Objective: Identify procedures relative to the procurement, contents, and security of publications used in aircraft maintenance.

- Items 2-1 and 2-2 refer to OPNAV Instruction 4790.2 (Series).

2-1. What is the major subject grouping of this Instruction?
1. Logistics
2. Financial Management
3. General Material
4. Aeronautical and Astronautical Material

2-2. The ".2" of this number indicates the
1. first change to OPNAV Instruction 4790.1
2. second amendment to OPNAV Instruction 4790
3. second change to OPNAV Instruction 4790
4. second Instruction that OPNAV issued under the subject classification number 4790

2-3. With which of the following subject groups will the AMH supervisor be least concerned?
1. Logistics
2. Operations and Readiness
3. General Administration and Management
4. Aeronautical and Astronautical Material

2-4. Which of the following is NOT a method of frame retrieval when operating the AR-150A Automatic Reader Printer?
1. Automatic
2. Manual motor driven
3. Manual hand wheel
4. Programmed selection

2-5. What is the maximum number of consecutive frames that may be printed for a continuous print with the AR-150A Automatic Reader Printer?
1. 5
2. 7
3. 9
4. 11

2-6. Letter-type technical directives are listed in the P2002 Section 111 by
1. type and directive number
2. consecutive number
3. serial number
4. equipment application

2-7. The listing of manuals that are available on specific items of aeronautical equipment is found in which of the following?
1. NAVAIR 00-500A
2. NAVAIR 00-500B
3. NAVAIR 00-500C
4. NAVSUP 2002, Part C

In items 2-8 through 2-10, select from column B the publication procurement method most closely associated with the statement listed in column A.

A. Statements	B. Procurement Methods
2-8. Aeronautical publications are provided by NATSF to a newly commissioned NAS.	1. Automatic Distribution lists
2-9. A request is made that future issues of a particular publication be received in the airframes work center.	2. Ordering direct
2-10. DD Form 1149 is submitted by a maintenance office for a particular letter type publication.	3. Initial outfitting
	4. Outfitting allowance

2-11. Discussing classified information over the telephone is strictly prohibited. This is especially important due to
1. scrambler systems failing
2. lines being tapped
3. microwave transmitters
4. codes being broken

2-12. An Airframe Bulletin giving instructions for a special inspection to be made of the arresting hook of all A-4 aircraft is received in the airframes work center. When filing this Bulletin, the first action that should be taken is to
1. determine the originator
2. assign the file symbol
3. determine the date of issue
4. determine if it should be placed in the operational or the management file

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Learning Objective: Recognize the supervisor's responsibilities relative to scheduling, assigning, and inspecting work assigned to his work center.

2-13. The factors that should receive the most consideration in estimating when an airframes work assignment should be satisfactorily completed are
1. manpower resources and training to be accomplished
2. available materials and scheduled inspections
3. manpower resources and scheduled inspections
4. manpower resources and available materials

2-14. Upon what basis should a senior AMH assign the work to be done?
1. On the basis of rate
2. On a rotational basis
3. According to seniority
4. According to proficiency

2-15. Which of the following is a desirable procedure for you to follow in making work assignments?
1. Arrange the workload so that the expert works in his specialty full time
2. Assume that there will be no work interruptions
3. Make sure that a man's first assignments involve complex as well as simple tasks
4. Assign an experienced man the task of training those who are less experienced

2-16. While inspecting work that is being done by airframes personnel, the supervisor should be chiefly concerned with
1. workmanship, materials, and compliance with current directives
2. workmanship, materials, and work methods
3. compliance with current directives, workmanship, and training
4. compliance with current directives, training, and work methods

2-17. During the final inspection of the work and completion of the Maintenance Action Form (VIDS/MAF), the supervisor is required to perform all of the following except to
1. determine if estimated maintenance time is realistically reflected in the crewleader's report of manhours used
2. evaluate the completed VIDS/MAF
3. compute the number of manhours expended
4. ensure that a functional check of a newly installed component is performed in accordance with existing directives

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Learning Objective: Recognize the key to and the individual responsibility for quality assurance in an airframes work center, and indicate the functional areas of quality assurance, how inspectors are designated, and the purpose of the quality assurance audit plan.

2-18. Which of the following is the most important element in quality assurance as it relates to all personnel in the work center?
1. Practical factor training
2. Promoting a positive mental attitude
3. Inspecting all facets of work
4. Performing work according to specifications

2-19. Which of the following statements relative to the functional areas of the quality assurance organization is INCORRECT? The division
1. coordinates the technical training program for the maintenance department
2. operates the technical library and monitors the dispersed libraries within the work centers
3. monitors management to assure compliance with the policies stated or implied within the NAMP Manual
4. verifies that all materials processed and actions taken by maintenance personnel meet prescribed quality requirements

2-20. Who has the responsibility for initiating and administering an airframes work center quality assurance program?
1. The shop supervisor
2. The commanding officer
3. The maintenance officer
4. The quality assurance officer

2-21. Collateral duty inspectors are designated in writing by the
1. division officer
2. commanding officer
3. maintenance officer
4. quality assurance officer

Learning Objective: Identify terms and procedures relating to advanced base operations.

2-22. A listing of manpower, equipment, and spare parts and supplies necessary to perform a specific task at an advanced base is known as a/an
1. initial outfitting list
2. advanced base list
3. detailed outfitting list
4. functional component

2-23. The letter H is used to designate which functional components?
1. Materials necessary for squadron use in carrying out a specific task at an advanced base
2. Personnel required to maintain a specific number of aircraft operating from an advanced base
3. Aviation materials, equipment, and personnel necessary for advanced base operation of aircraft under combat conditions
4. Materials which must be used to supplement those given in the Advanced Base Outfitting Lists for a squadron operating from an advanced base

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Learning Objective: Recognize procedures for organizing and administering an airframes work center training program.

2-24. Which grouping is least representative of actions required by a work center supervisor in establishing and administering a work center training program?
1. Selecting instructors, scheduling training periods, lesson planning
2. Procuring training aids, qualifying instructors, arranging for classrooms
3. Scheduling training periods, procuring visual training aids, selecting and qualifying instructors
4. Determining that a training program is needed, lesson planning, selecting and training instructors

2-25. Which of the following statements concerning training is correct?
1. Before an AMH3 may be advanced, he must demonstrate proper teaching techniques
2. Because of varying workloads, no attempt should be made to schedule training on a prearranged schedule
3. An AMH3 must properly use training aids in teaching a class before he is eligible for advancement
4. The three major subject areas of work center training are safety, advancement, and aircraft maintenance

2-26. Before being advanced to what rate level is the AMH first required to demonstrate his ability to formally teach, use training aids, and administer written exams?
1. AMH3
2. AMH2
3. AMH1
4. AMHC

2-27. In administering a training program, lesson plans are used to
1. ensure that the subject matter will be covered
2. set forth the objective of the lesson
3. summarize the main points of the lesson
4. ensure that the subject matter, even if taught by different instructors, will be presented in the same manner to each class

2-28. Which of the following statements is least descriptive of informal training?
1. It is on-the-job training
2. It does not require special training equipment
3. It is easier to work into the daily work schedule than formal training
4. It is performed under the supervision of the work center supervisor

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Learning Objective: Indicate a familiarity with publications relating to aviation safety, and recognize the levels of responsibility for safety programs and factors that may contribute to unsafe working conditions.

2-29. Responsibility for direction and supervision of the Department of the Navy Safety Program is assigned to the
1. Naval Safety Center
2. Chief of Naval Operations
3. Naval Air Systems Command
4. Naval Ships Systems Command

2-30. The most accurate information on maintenance-caused mishap prevention and general aviation ground safety is
1. MECH
2. Approach
3. Crossfeed
4. Naval Aviation News

2-31. Overall responsibility for the maintenance department safety program is assigned to the
1. squadron safety officer
2. quality assurance officer
3. assistant maintenance officer
4. maintenance/material control officer

Learning Objective: Recognize the procedures and responsibilities for organizing and administering a work center safety program and identify fire hazard precautions in the work center and hangar space.

2-32. Which of these words are used for mandatory precautions listed in Safety Precautions for Shore Activities, NAVMAT Publication P-5100?
1. Shall, will, and must
2. May, should, and will
3. Prohibited, shall, and must
4. Will, shall, and prohibited

2-33. All but which of the following statements relative to the interpretation and enforcement of safety directives and precautions are true?
1. The supervisor is responsible for correctly interpreting new posters and safety precautions and their application to his men
2. The supervisor must apply both the safety precautions in the Safety Precautions for Shore Activities and the local precautions specified by his command
3. If an occasion should arise when the specific application of a directive is in doubt, the measures to be taken should be consistent with those which will achieve maximum safety
4. The safety officer is responsible for interpreting safety directives to the supervisor and to specify the means whereby they can be used

2-34. All but which of the following procedures should be followed to prevent fire hazards in the shop or hangar space?
1. Spilled grease, oil, and chemicals should be wiped up immediately
2. All used rags should be placed in cardboard boxes for disposal
3. Static electrical buildups should be prevented during maintenance by installing ground wires on the aircraft
4. "No Smoking" rules should be enforced

2-35. Which of the statements below best describes the duties of an airframes supervisor in administering an adequate accident-prevention program?
1. He must inspect work areas and check for potential hazards
2. He must inspect equipment and tools, enforce safety rules, and check for malingering
3. He must check equipment to ensure against accidents, enforce attendance rules, and ensure correct work methods
4. He must inspect equipment and work areas, check for potential hazards enforce safety rules, and assure correct operating procedures

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Learning Objective: Recognize the development, organization, and functions of aviation supply.

2-36. What is the sequential development of the aviation supply system?
1. NAF, BUAER, ASO under BUAER and BUSANDA, ASO under NAVAIRSYSCOM
2. NAF, BUAER, BUSANDA, ASO under BUAER and BUSANDA, ASO under NAVAIRSYSCOM
3. NAF, BUAER, ASO under BUAER and BUSANDA, ASO under NAVAIRSYSCOM
4. NAF, BUAER, ASO under BUAER and BUSANDA, ASO under NAVAIRSYSCOM and NAVSUPSYSCOM

2-37. In what way, if any, is ASO related to the NAVAIRSYSCOM?
1. It is under the technical control of the NAVAIRSYSCOM
2. It is under the management control of the NAVAIRSYSCOM
3. It operates independently of the NAVAIRSYSCOM
4. No way; it is under the management and technical control of the NAVAIRSYSCOM

2-38. Which of the following is NOT a function of the Naval Supply Systems Command (NAVSUP)?
1. Administering the sale of surplus Navy property
2. Authorizing and supervising the transportation of Navy property
3. Coordinating the Compilation of and arranges for the printing of the catalog of Navy Material
4. Supervising the procurement, receipt, custody, warehousing, and issuance of Navy medical supplies

2-39. Which of the following is NOT a function of ASO?
1. Procurement and distribution of complete aircraft and engines
2. Maintenance of an ASO representative at each aircraft manufacturer's plant
3. Compilation and distribution of some allowance lists subject to approval by NAVAIRSYSCOM
4. Distribution of copies of ASO and NAVAIRSYSCOM contracts to the cognizant Navy field activities

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Learning Objective: Identify how funds are appropriated and the types and uses of budgets that are allocated.

2-40. Funds are released to agencies of the federal government by
1. presidential approval for SECDEF action
2. presidential approval for Treasury Department action
3. congressional action with presidential approval
4. the House of Representatives with presidential approval

In items 2-41 and 2-42, select from column B the appropriation indicated by the definition in column A.

	A. Definitions	B. Appropriations
2-41.	Money for projects that will be completed in a predictable length of time	1. One-year 2. No-year 3. Multiple-year
2-42.	Money the Department of Defense will spend in a specified year	

2-43. Which of the following appropriations will concern you the most as an AM in charge of an airframes branch within a maintenance department?
1. No-year appropriation
2. Multiple-year appropriation
3. Four-year appropriation
4. Current one-year appropriation

2-44. The procedure whereby CNO authorizes a user activity to spend money for a definite purpose and for a specific time is called a/an
1. commitment
2. operating target
3. budget
4. authorization

2-45. Which source of funds is of most concern to a senior AMH assigned to a squadron aboard an aircraft carrier?
1. Operating Target (OPTAR)
2. Operation and Maintenance allotment
3. Aviation Fleet Maintenance allotment
4. APA allotment

2-46. The types of OPTARS of interest to senior AMHs are identified as
1. operations and line maintenance of aircraft funds
2. aircraft rework and research allotments
3. station operation and maintenance allotments
4. flight operations and aircraft maintenance funds

2-47. Flight operation funds are used primarily to finance all but which of the following?
1. Aerial film for use in aircraft cameras
2. Fuels and lubricants consumed by aircraft engines in the performance of a complete section repair
3. Squadron administrative consumable office supplies
4. Aviation fuels and lubricants used in aircraft

2-48. Aircraft maintenance funds have application at which of the maintenance levels?
1. Depot
2. Intermediate only
3. Organizational only
4. Organizational and intermediate

Learning Objective: Indicate methods and publications used in identifying materials to be procured, interpret selected identifying data, and recognize the use of repair kits.

2-49. Before the Defense cataloging Standardization Act, one agency of the federal government could not tell if its material held in short supply was held in excess by another agency. This deficiency was corrected by
1. the National Stock Numbering System
2. the cross-reference system
3. the cognizance symbols
4. the material control codes

2-50. Before passage of the Defense Cataloging Standardization Act, the main cause of excess inventories was the lack of
1. standardization
2. competitive bidding
3. a system for cataloging stocks
4. a system for numbering items

● Items 2-51 through 2-57 refer to the national stock number (NSN) 2R H F 1630-00-123-4567-BF and to tables 3-1 and 3-2 in your textbook.

2-51. This NSN is a Navy-coded NSN because it contains
1. a prefix and suffix
2. an identifying cognizance symbol
3. 11 digits arranged in groups of 4,3, and 4
4. a federal supply class (FSC) number and a national identification number (NIIN)

2-52. This item is under the inventory control of the
1. Navy Fleet Material Support Office
2. Naval Air Systems Command
3. Aviation Supply Office
4 Electronics Supply Office

2-53. The letter H indicates that this item is
1. nonrepairable
2. capable of being repaired by depot maintenance activities
3. capable of being repaired by intermediate maintenance activities
4. subject to special transaction reporting from acquisition to final disposition

2-54. What part of this number indicates whether the material is ready for issue and use?
1. BF
2. F
3. H
4. R

2-55. Which of the codes is subject to change?
1. BF
2. F
3. H
4. 2R

2-56. What class of commodities is indicated by the federal supply classification class?
1. Aircraft propellers
2. Aircraft wheel and brake systems
3. Aircraft landing gear components
4. Aircraft and airframes structural components

2-57. What is its NIIN?
1. 1630
2. 1630-00-123
3. 00-123
4. 00-123-4567

2-58. What management code will be suffixed to an NSN to identify items with aircraft models?
1. NIIN
2. NISC
3. SMIC
4. TSMC

2-59. For a material category to be exempt from the federal cataloging system, it must meet which of these requirements?
1. Be consumable
2. Be identified by an NSN
3. Consist of 12 characters
4. Appear in requisitions

2-60. Which material control code is used to signify a local item control number?
1. GG
2. LL
3. QQ
4. XX

2-61. Another word for nomenclature is
1. character
2. number
3. name
4. stock

2-62. What is the best source for the identification of an aircraft part if only the manufacturer's part number is known?
1. Cataloging Handbook, H4-1
2. Federal Classification Handbook
3. Initial Outfitting List for the aircraft
4. Illustrated Parts Breakdown for the aircraft

2-63. If you needed the total quantity of each part used in an aircraft, you should look in which section of the Illustrated Parts Breakdown?
1. Master Locator Index
2. Group Assembly Parts List
3. Numerical Index
4. Index Manual for the IPB

2-64. For some aircraft IPBs, the Numerical Index has been replaced by the
1. Group Assembly Parts List
2. Illustrated Shopping Guide
3. Master Locator Index
4. Illustrated Maintenance Parts List

2-65. If a failed part is not listed in the IPB because it was installed as the result of a technical directive, what source should you consult?
1. Master Locator Index
2. Index Manual for the IPB
3. Group Assembly Parts List
4. Illustrated Maintenance Parts List

In items 2-66 through 2-68, select from column B the type of identification data that may be utilized for each purpose listed in column A.

A. Purposes

2-66. To provide information that proves very helpful when requesting material not subject to the federal cataloging system

2-67. To provide data which, when cross-referenced to an applicable microfilm, supplies sufficient information on a component that is not fully identified in the appropriate IPB

2-68. To provide special coded markings, other than part numbers, for identifying material

B. Identification Data

1. Nameplate
2. Drawing number
3. Specification number
4. Markings and measurements

2-69. If cure-date items must be utilized, which statement applies to the use of repair kits?
1. C and D kits are never used together
2. The use of an F kit requires the use of a C kit
3. The use of a D kit requires the use of an F kit
4. The use of a D kit requires the use of a C kit

Assignment 3

Aviation Supply and Corrosion Control

Text: Pages 84 - 122

Learning Objective: Determine the activity responsible for initiating, updating, and modifying aeronautical allowance lists, and recognize the contents, accountability codes, purposes, and utilization of the various lists.

3-1. Which activity has the responsibility for the continual review and updating of aeronautical allowance lists?
1. ASO
2. NAVSUPSYSCOM
3. NAVAIRSYSCOM
4. DCNO (Air)

In items 3-2 through 3-4, select from column B the list or table most closely associated with the statement in column A.

	A. Statements	B. Lists/Table
3-2.	It contains a listing of tools, equipment, and spare parts required by activities for performance of their assigned missions	1. Allowance
		2. Initial outfitting
3-3.	It contains a listing of maintenance spare parts to support various aeronautical end items	3. Table of Basic Allowance
		4. Table of Organization
3-4.	It contains a listing of equipment used on a continual basis for maintenance of aircraft	

3-5. Which of these publications contains the other three?
1. Aeronautical Allowance Lists
2. NAVSUP Publication 2002
3. Tables of Basic Allowance
4. Initial Outfitting Lists

3-6. Which section of an allowance list should be used to identify aircraft spare parts?
1. B
2. G
3. M
4. T

3-7. Which section of the IOL contains items and quantities of flight operational material necessary to maintain the concerned activities in a continual condition of operational readiness?
1. A
2. B
3. G
4. H

3-8. Who may authorize deviations from allowance list requirements?
1. Major operating commanders
2. Force commanders
3. Type commanders
4. Each of the above

3-9. Which echelon of aviation supply normally identifies the activity to evaluate a prototype, a new piece of equipment that deviates from the allowance list?
1. Force commander
2. ASO
3. NAVAIRSUPCOM
4. Type commander

3-10. Data and documentation needed to determine and establish support equipment requirements and inventory control of aircraft maintenance support equipment is provided in the
1. Application Data Material Readiness List (ADMRL)
2. Aeronautical Allowance List
3. Aircraft Maintenance Material Readiness List (AMMRL)
4. Individual Material Readiness List (IMRL)

3-11. The NIIN sequence cross-reference, the noun sequence cross-reference, and the avionics cross-reference are all parts of the
1. Individual Material Readiness List (IMRL)
2. Application Data Material Readiness Lists (ADMRL)
3. Table of Basic Allowances
4. Initial Outfitting Lists

3-12. The mandatory material readiness list of an activity is the applicable
1. ADMRL
2. AMMRL
3. IMRL
4. Aeronautical Allowance List

Learning Objective: Recognize the reasons for the Management Programs for Aviation Repairables, the elements of the programs, and the key officials responsible for the success of the programs.

3-13. Which of these options includes the other three?
1. High Value Asset Control
2. Management Program for Aviation Repairables
3. Close Loop Aeronautical Management Program
4. Navy Integrated Comprehensive Repairable Item Scheduling Program

3-14. What material control code is assigned to repairable HIVAC items?
1. G
2. J
3. K
4. R

3-15. What is a target of an ASO-directed level O repair under NICRISP?
1. Next 60 days
2. Next 30 days
3. Next 20 days
4. NORS backorder

3-16. Which adjective best fits the type of items in the Close Loop Aeronautical Management Program?
1. Noncritical
2. Surplus
3. Critical
4. Obsolete

3-17. To be considered as critical under CLAMP, an item must have a unit cost of at least
1. $1,000
2. $5,000
3. $10,000
4. $100,000

3-18. AFR means
1. Aeronautical Field Representative
2. Aviation Supply Field Representative
3. Aviation CLAMP Field Representative
4. ASO Field Representative

3-19. Under CLAMP an AFR reports to his
1. NAVAIRSYSCOMREP
2. ASO program manager
3. base commanding officer
4. auditor

3-20. How many, if any, copies plus the original of the DD Form 1348/1 must be included in each shipment under CLAMP?
1. 1
2. 2
3. 3
4. 0

3-21. An AFR assigned to a DOP maintains each of these records EXCEPT the
1. serial number record
2. shipment record
3. AFR master log
4. receipt record

Learning Objective: Identify functions of maintenance activity material control work centers, and recognize procedures and priority codes used in requisitioning and turning in material.

3-22. When an aircraft component is received in an intermediate maintenance activity for repair, the administrative screening unit of the material control work center performs all but which of the following functions?
1. Schedules the repair of the component
2. Identifies the component positively
3. Determines if the repair of the component is within the repair capabilities of the activity
4. Assures that all logs, records, and MAFs are affixed to the component

3-23. The proper priority to be assigned to material requisitioned on a Form DD 1348 is determined by
1. military classification of the requesting unit and end use of the material
2. urgency of need for the material and its end use
3. type of force making the request and the military classification of the material
4. urgency of need for the material and the military importance to the requesting unit

- Refer to table 3-5 in your textbook to answer items 3-24 through 3-26.

3-24. Which combination of force/activity designation and urgency-of-need category has the highest priority?
1. I C
2. II C
3. III B
4. IV A

3-25. Which issue priority designator (IPD) is used for medical supplies to prolong life?
1. 01
2. 02
3. 03
4. 04

3-26. What is the urgency-of-need designator for parts needed for emergency repair of an aircraft incapable of flight or of performing its primary mission?
1. I
2. II
3. A
4. D

3-27. What is the correct distribution of copies 2, 3, and 4 of the MAF that is required for turning in a defective repairable item?
1. Copies 2 and 4 are sent to supply, and copy 3 accompanies the item to AIMD
2. Copies 2 and 3 are sent to AIMD, and copy 4 accompanies the item to supply
3. Copy 2 is sent to supply, and copies 3 and 4 accompany the item to AIMD
4. Copies 2 and 3 are sent to supply, and copy 4 accompanies the item to AIMD

Learning Objective: Recognize the administrative responsibility for the corrosion control program and the considerations in selecting metals for aircraft construction.

3-28. The primary factor that a manufacturer must consider in selecting metals for aircraft construction is their
1. cost
2. strength-to-weight ratio
3. corrosion-resistant properties
4. metal fatigue-resistant properties

3-29. Which unit of an activity involved in maintaining aircraft is responsible for coordinating and directing the activity's corrosion control efforts?
1. Maintenance/production control
2. Quality assurance
3. Administration
4. Analysis

Learning Objective: Recognize the purposes of metal finishing and identify materials and processes used for protecting metals.

3-30. What is the main purpose of metal finishing?
1. Increase wear resistance
2. Provide corrosion resistance
3. Decrease resistance to airflow
4. Provide a suitable base for paint

3-31. If the main purpose of electroplating metal is to increase its resistance to tarnish, which of the following plate materials should be used?
1. Tin
2. Zinc
3. Nickel
4. Cadmium

3-32. Which metal-protecting process affects only slightly the thickness of the metal being coated?
1. Gold-plating
2. Anodizing
3. Cadmium-plating
4. Chromium-plating

Learning Objective: Identify extent of corrosion damage, the nature and appearance of corrosion products, corrosion-resistant metals, requirements for corrosion to take place, and methods of identifying various types of corrosion in corrosion-prone areas.

3-33. Refer to figure 4-2 in your textbook. Which group of metals, when used in contact with each other, is least likely to require protection separators to prevent corrosion?
1. Carbon steel and nickel
2. Zinc plate and magnesium
3. Titanium and copper
4. Corrosion-resisting steel and tin

3-34. Which process generally protects steel bolts, nuts, and screws from corrosion?
1. Passivation
2. Cadmium plating
3. Chromium plating
4. Zinc-chromate priming

3-35. What process develops corrosion-resistant properties of stainless steel during fabrication?
1. Cladding
2. Passivation
3. Anodizing
4. Electroplating

3-36. Which metal requires the most insulation from all other dissimilar metals which it might contact?
1. Nickel alloy
2. Titanium alloy
3. Magnesium alloy
4. Corrosion-resistant steel

Learning Objective: Recognize the importance of aircraft cleanliness and indicate requirements and procedures applicable to corrosion prevention.

3-37. Some engines are operated in a salt-water environment and ingest salt water or mist into their compressor inlets. When should these engines be washed or sprayed with Rust-Lick #606 preservative?
1. Before each flight
2. After each flight
3. After the last flight of the day
4. During their periodic inspections

3-38. Which lubrication points are you LEAST likely to neglect when lubricating exposed areas after cleaning?
1. Out-of-the-way flush-type pressure lubrication points
2. Landing-gear and wing-fold lubrication points equipped with Zerk fittings
3. Hinges and latches lubricated by a squirt can
4. Sliding surfaces lubricated by a squirt can

3-39. Extreme care must be exercised in using a mixture of methanol and water to wash an engine because methanol is extremely
1. caustic and flammable only
2. flammable and toxic only
3. toxic and caustic only
4. toxic, caustic, and flammable

3-40. If a protective coating is scarred or etched by corrosion damage, the damage is said to be
1. minor
2. significant
3. repairable
4. replaceable

Learning Objective: Identify types of corrosion and types of preservation.

● Refer to table 4-1 in your textbook in answering items 3-41 through 3-43.

In items 3-41 through 3-43, select from column B the appearance of the corrosion product of the alloy listed in column A.

	A. Alloys		B. Corrosion Product Appearances
3-41.	Aluminum	1.	Reddish-brown oxide
3-42.	Magnesium	2.	White powdery snow-like mounds and white spots on the surface
3-43.	Copper	3.	Blue or blue-green powder
		4.	White or gray powder

3-44. Which of the following is NOT an indication of microbiological corrosion?
1. Surface bulges
2. Fungus deposits
3. Green to brown residues
4. Residues with a slimy texture

3-45. What is the most common cause of corrosion in Metalite?
1. Oxidation
2. Microbiological growth
3. Internal stress
4. Water collection or penetration

3-46. If an operating activity is to keep two of its aircraft in an idle condition for 60 to 90 days, what type preservation should be used on them?
1. A
2. B
3. C
4. D

3-47. Which type preservation must be applied to an aircraft if foam was used to extinguish a fire after a crash landing?
1. B
2. C
3. D
4. E

Learning Objective: Recognize reasons for complete corrosion removal and indicate materials, tools, procedures, and precautions for removing surface coatings and corrosion products.

3-48. Whenever possible, paint films should be removed with
1. sandpaper
2. paint thinners
3. glass vacu-blast beads
4. abrasive-webbing nylon mats

In items 4-49 through 4-51, select from column B the paint remover recommeded for use on the type of surface listed in column A.

	A. Surface Coatings	B. Paint Removers
3-49.	Enamel	1. Fluorescent paint remover MIL-R-21972
3-50.	Acrylic	2. Paint remover conforming to MIL-R-18553
3-51.	Wax	3. Epoxy remover, MIL-R-81294
		4. Nonphenolic paint and lacquer solvent remover conforming to specification TT-R-248

3-52. Which of these procedures is WRONG in using paint removers?
1. Mask off all areas where contact with the stripper is not desired
2. Apply the stripper with a brushing motion
3. Allow the stripper to remain on the surface until the wrinkled appearance of the paint film indicates that the paint is soft or lifted
4. Remove the residual stripper and loose paint by washing and scrubbing the surface with a low- or medium-pressure spray of water

3-53. Which substance should be used to remove a decal in an area where heat lamps are prohibited?
1. Methyl ethyl ketone
2. Pennsalts E-Z Strip 19A
3. Methyl isobutyl ketone
4. A mixture of toluene and isopropyl alcohol

3-54. What should be used to remove medium corrosive residue from irregular surfaces. and pitted areas?
1. Vacu-blast abrasive glass beads
2. Aluminum oxide nylon webbing
3. Aluminum oxide abrasive paper
4. An aluminum oxide abrasive-bonded nylon wheel

3-55. When working with anodized aluminum alloys, be very careful to
1. apply a highly buffed finish
2. preserve the oxide film
3. remove heavy corrosion with steel wool
4. remove the protective coating with chromic acid

Learning Objective: Recognize the methods of removing corrosion from metals or alloys.

In items 3-56 through 3-58, select from column B the approved tool or material for removing corrosion from the type of metal surface listed in column A.

	A. Surfaces		B. Tools/Materials
3-56.	Exfoliated	1.	Abrasive-impregnated nylon webbing
3-57.	Anodized	2.	Vacu-blast dry honer
3-58.	Clad	3.	Abrasive-impregnated nylon wheel
		4.	Metal polish conforming to MIL-P-6888

3-59. All of the following methods may be used to remove corrosion from high-strength steel parts EXCEPT
1. vacu-blasting with glass beads
2. hand-rubbing with 300- or 400-grit aluminum oxide paper
3. power-buffing with compounds
4. hand-rubbing with fine grit abrasive-impregnated nylon webbing

In items 3-60 through 3-63, select from column B a method of removing corrosion from the metal or alloy listed in column A.

	A. Metals/Alloys		B. Methods
3-60.	Magnesium	1.	Immersing in a 10-percent solution of citric acid followed by rinsing with fresh water
3-61.	Stainless steel	2.	Hand-rubbing with abrasive-impregnated nylon webbing, vacu-blasting with abrasive glass beads, and cleaning with a water-emulsion cleaning solution
3-62.	Titanium	3.	Cleaning with P-D-680 solvent, hand rubbing with abrasive impregnated nylon webbing, and cleaning with a water emulsion cleaning solution
3-63.	Copper alloy		

Assignment 4

Nondestructive Inspection of Metals and Power System Maintenance

Text: Pages 125 - 177

Learning Objective: Identify terms, uses, and application procedures and results of the magnetic particle inspection.

In items 4-1 through 4-3, select from column B the definition of the term in column A.

	A. Terms		B. Definitions
4-1.	Permeability	1.	The pattern formed by the magnetized particles in the magnetic field between the opposite poles
4-2.	Discontinuity	2.	The ease with which a magnetic flux can be established in a magnetic circuit
4-3.	Indication	3.	The ferromagnetic particles which are flushed or dusted over the part being tested or in which the part is immersed
		4.	An interruption in the normal physical structure or configuration of a part

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4-4. The magnetic particle inspection is unreliable for detecting
1. laps
2. cold shuts
3. hairline discontinuities
4. discontinuities considerably below the surface

4-5. Which type of discontinuity is formed by a rupture of the metal?
1. Lap
2. Pipe
3. Cold shut
4. Inclusion

4-6. Which type of discontinuity will be formed if, during the melting of the basic metal, bits of the furnace lining are picked up by the metal?
1. Void
2. Seam
3. Cold shut
4. Inclusion

Learning Objective: Recognize induction procedures and characteristics of methods used in the magnetization process, associated indications produced with various types of discontinuities, and areas to consider when interpreting results.

4-7. Refer to figure 5-8 in text. Which defects will NOT produce indications if a part is magnetized by continuous longitudinal magnetization with a cable?
1. Defects perpendicular to the axis of the part
2. Defects running from the center of the part out
3. Circular defects running around the part
4. Defects parallel to the axis of the part

4-8. Which method of magnetization produces the greatest sensitivity in locating subsurface discontinuities?
1. Residual circular with a conductor bar
2. Residual longitudinal with a conductor bar
3. Continuous longitudinal with a coil
4. Residual longitudinal with a coil

4-9. Which statement relating to the continuous magnetizing inspection method is false?

1. It is used with both the wet and dry indicating mediums
2. Its indicating medium is applied when the magnetizing force is being maintained
3. It may NOT be used with steels which have been heat-treated for stressed applications
4. It requires careful and intelligent interpretation and evaluation of the discontinuities it reveals

4-10. Which of the following open-to-surface discontinuities produce the most readily distinguished indications?

1. Pipes
2. Cracks
3. Seams
4. Hairlines

4-11. Which type of crack will probably cause the most buildup in the indicating medium?

1. Fatigue
2. Heat-treat
3. Shrink
4. Grinding

4-12. Which discontinuities are formed by nonmetallic materials trapped in the ingot during solidification?

1. Laps
2. Hairlines
3. Inclusions
4. Segregations

4-13. Unlike the indication of a crack, the indication of an open inclusion usually consists of

1. a symmetrical pattern
2. a heavy buildup
3. a smooth outline
4. parallel lines

4-14. The magnetic particle inspection method is unreliable for detecting

1. hairlines
2. segregations
3. pipes considerably below the surface
4. nonmetallic inclusions

Learning Objective: Recognize characteristics, uses, and components of various magnetizing units.

4-15. Refer to figure 5-14 in your textbook. Longitudinal magnetization is produced by which of the indicated components?

1. Contact heads
2. Nozzle
3. Coil
4. Contacts and pressure spring

4-16. In testing a crankshaft with a general-purpose portable magnetizing unit, longitudinal magnetization can be developed by

1. wrapping the cable around the crankshaft
2. using the contact prods
3. using the contact clamps
4. using the residual method

4-17. During automatic demagnetization with the general-purpose portable magnetizing unit, the output current is reduced by the

1. prod assembly switch
2. control cable switch
3. motor-drivem DEMAG switch
4. motor-driven rotary switch

4-18. What is the purpose of providing prods with the standard general-purpose magnetizing unit?

1. To eliminate the necessity for bolted connections when using contact blocks
2. To permit testing of parts where it is impractical to use clamps
3. To prevent burning of the contact areas
4. To permit testing of propeller blades

Learning Objective: Recognize the liquid vehicles for wet suspension, the qualities the indicating medium must possess, and how the medium is mixed and applied.

4-19. Which qualities must the indicating medium for magnetic particle inspection possess for acceptable operation?

1. High permeability and low retentivity
2. Low permeability and low retentivity
3. High permeability and high retentivity
4. Low permeability and high retentivity

4-20. Before the magnetic paste is added to the tank of suspension liquid, the paste must be mixed with a small amount of

1. dry magnetic powder
2. suspension fluid
3. petroleum jelly
4. water

4-21. Dry magnetic particles may be applied by which of these methods?
1. Rolling the magnetized part in the particles
2. Pouring the particles directly on the surface of the magnetized part
3. Floating the particles to the surface of the magnetized part
4. Any of the above methods

Learning Objective: Identify the type and source of current for demagnetizing parts and the method of demagnetizing a part by the narrow coil demagnetizer.

4-22. Demagnetization of a part is NOT required if the part is to be heat treated to what temperature?
1. 1200° F
2. 1500° F
3. 1700° F
4. 1900° F

4-23. Which type of current is usually used to demagnetize aircraft parts?
1. Direct, increasing
2. Alternating, increasing
3. Alternating, decreasing
4. Direct, decreasing

4-24. What is the minimum distance a part must be removed from the demagnetizing equipment before the demagnetizing current is cut?
1. 1 to 2 feet
2. 2 to 3 feet
3. 3 to 4 feet
4. 4 to 5 feet

Learning Objective: Recognize the types and characteristics of hydraulic power systems and their component functions.

4-25. Which component of an open-center hydraulic system prevents pressure buildup until a demand is placed on the system?
1. Bypass valve
2. Relief valve
3. Selector valve
4. Pressure regulator

4-26. After the actuating mechanism has reached the end of its operating cycle, the open-center system will cause pump output to continue until the system relief valve setting is reached. How are the selector valves operated in this system?
1. Manually engaged and pressure disengaged
2. Manually engaged and manually disengaged
3. Pressure engaged and pressure disengaged
4. Pressure engaged and manually disengaged

Items 4-27 through 4-29 are for the hydraulic power system of the E-1B aircraft.

4-27. What is the name for this system?
1. PC-2
2. Power control
3. Hydraulic/mechanical
4. Utility

4-28. Which unit protects the system from too much pressure if a pump pressure control unit fails?
1. Check valve
2. Selector valve
3. Pressure relief valve
4. Hydraulic pump

4-29. The purpose of the pressure line check valves is to
1. ensure that both pumps deliver approximately the same volume of pressurized fluid
2. meter fluid as it enters the pressure side of the system
3. prevent pressurized fluid from flowing from a hydraulic pump
4. prevent pressurized fluid from flowing to a hydraulic pump

4-30. If the reservoir contains an adequate amount of fluid, what assures a constant supply of fluid to the pump?
1. Pressurized air
2. Booster pump
3. Priority valve
4. Relief valve

Learning Objective: Identify causes of hydraulic system troubles and recognize aids and procedures used to maintain hydraulic systems.

In items 4-31 through 4-34, select from column B a possible cause of the hydraulic system trouble listed in column A.

	A. Troubles		B. Causes
4-31.	Pressure fluctuates	1.	Check valves installed backward
4-32.	Low pump pressure	2.	Defective relief valve
4-33.	Overheated pump	3.	Defective pump
4-34.	No fluid delivered		

4-35. The first thing you should do if a hydraulic pressure indicator fluctuates continuously is to
1. replace the pump
2. adjust the indicator
3. determine if the trouble is electrical, hydraulic, or mechanical
4. replace the indicator

4-36. Which diagram shows how a component fits with other components of a system but does not tell where it is in the aircraft?
1. Schematic
2. Installation
3. Combination schematic and installation
4. Pictorial

4-37. How are symbols and drawings used in diagrams?
1. Symbols only are employed in both schematic and installation diagrams
2. Actual drawings only are employed in both schematic and installation diagrams
3. Symbols are employed in schematic diagrams and actual drawings are employed in installation diagrams
4. Symbols are employed in installation diagrams and actual drawings are employed in schematic diagrams

4-38. In troubleshooting, you need a multimeter to
1. relieve the AE of solving electrical problems
2. be able to read the electrical portion of a hydraulic schematic diagram
3. see if the problem is electrical or hydraulic
4. check voltage and continuity

4-39. Which pressure indication is most likely when the pressure regulator in a closed-center system is stuck in the cut-out position?
1. Zero
2. Above normal
3. Below normal
4. Fluctuating

Learning Objective: Indicate causes of hydraulic system leaks and procedures for their detection and repair.

4-40. Which of the following is LEAST likely to cause internal leakage?
1. Cross-threaded fitting
2. Worn sealing device
3. Valve not seating
4. Contaminated hydraulic fluid

4-41. If you find hydraulic fluid around shaft seals, you, an experienced troubleshooter, should conclude first that
1. the leakage is normal
2. a malfunction exists
3. the system must be secured
4. fittings should be tightened or repacked

Items 4-42 through 4-46 use the Model 4918A Ultrasonic Leak Detection Translator.

4-42. What principle is applied in the translator to make it useful to you?
1. Sound waves you cannot hear become sound waves your ear picks up
2. Ultrasonic leaks become sonic leaks
3. Pressure or vacuum leaks create ultrasonic sound waves
4. Ultrasonic leaks are identified and discriminated

4-43. Which sounds come from the interaction of higher-velocity air or gas molecules within the atmosphere?
1. Frying
2. Pulsed
3. Rhythmic
4. Hissing

4-44. What is the input to the contact probe?
1. Acoustic energy of any level transmitted through the atmosphere
2. Acoustic energy of discriminate levels transmitted through the atmosphere
3. Sonic energy released within the metal structure of the aircraft
4. Mechanical energy conducted from the ultrasonic source

4-45. What device converts mechanic energy into an electric signal?
1. Headset
2. Probe
3. Intensity meter
4. Crystal transducer

4-46. What happens to the output from the crystal transducer?
1. Identified
2. Converted
3. Amplified
4. Divided

4-47. What should you do if the right MIM is not on hand as you get ready to remove hydraulic equipment?
1. Go ahead with the job, because you should know what the MIM says
2. Devise your own procedure but check the MIM later
3. Wait until you get the right MIM
4. Follow shop practice

4-48. Which of the following statements is true relative to the removal and installation of hydraulic equipment?
1. The primary reason for capping or plugging the open ends of lines after equipment has been removed is to prevent fluid from dripping on electrical wiring and other surfaces
2. A water soaked cloth placed beneath open lines will prevent hydraulic fluid from dripping on electrical wiring and other surfaces
3. Fluid lines may not be removed from pressurized bulkheads
4. Hydraulic systems are designed in such manner that lines may not be cross-connected

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Learning Objective: Recognize operational characteristics, component functions, and removal and installation procedures of hydraulic pumps.

In items 4-49 through 4-51, select from column B the function performed by the component of the Kellog Variable Displacement Pump listed in column A.

A. Components

4-49. Stroking piston

4-50. Holddown plate

4-51. Inclined cam plate

B. Functions

1. Aligns the high-pressure ports
2. Forces the pistons into the bores
3. Retracts the pistons from the bores
4. Varies the cam plate angle

4-52. If system pressure is 2,950 psi, what is the approximate number in gallons per minute (gpm) of fluid delivered by the pump?
1. Zero
2. Six
3. Seven
4. Eight

4-53. In what order should the hydraulic lines be disconnected to remove an engine-driven hydraulic pump on the A-6A aircraft?
1. Suction, bypass, and pressure
2. Bypass, pressure, and suction
3. Bypass, suction, and pressure
4. Pressure, suction, and bypass

Learning Objective: Identify power system components, their functions and operating characteristics, and recognize associated maintenance procedures.

4-54. Pressurized air may be supplied to the reservoir from how many different sources?
1. Five
2. Two
3. Three
4. Four

4-55. To remove air from the upper chamber of the reservoir, the air is vented through
1. the air dump valve
2. the air dump valve or the poppet valve
3. either the air pressure regulator or the air dump valve
4. the air pressure valve to the air storage tank

4-56. When the fill selector valve is in the No. 1 reservoir position, what is the sequence of actions before hydraulic fluid can enter the tank reservoir?
1. Reservoir pressure dumps → fluid enters fill line → pressure-operated vent valve opens → back-pressure valve opens
2. Fluid enters fill line → pressure-operated vent valve opens → back-pressure valve opens → reservoir pressure dumps
3. Fluid enters fill line → reservoir pressure dumps → poppet valve opens → back-pressure valve opens
4. Fluid enters fill line → pressure-operated vent valve opens → reservoir pressure dumps → back-pressure valve opens

4-57. Which condition must exist for the reservoir to be repressurized?
1. Fill selector valve in the OFF position
2. Pressure-operated vent valve open
3. Fill-line back-pressure valve open
4. Fill-selector valve in either the No. 1 or No. 2 position

In items 4-58 through 4-60, select from column B the component which performs the function in a fluid-pressurized reservoir as listed in column A.

A. Functions

4-58. Protects the reservoir from excessive hydraulic pressures

4-59. Exerts system hydraulic pressure against reservoir fluid

4-60. Enables entrapped air to be removed from the reservoir

B. Components

1. Manual bleed valve
2. Diaphragm
3. Reservoir relief valve
4. Corrugated shield

4-61. How is the fluid pressurized in a fluid-pressurized reservoir?
1. Pressurized air is admitted to the tank chamber and exerts force directly on the fluid
2. System fluid pressure operating through a piston passage exerts force against a diaphragm
3. System fluid pressure overrides a relief valve and pressurizes the lower tank chamber
4. System fluid pressure operating through a relief valve exerts force against the diaphragm

4-62. What should you do to determine when the tank chamber of a fluid-pressurized reservoir is adequately filled?
1. Apply pressure until all air is removed from the sight gage
2. Apply pressure until fluid begins to flow from the bleed valve
3. Apply pressure until fluid begins to flow from the overboard drain
4. Observe the sight gage

Assignment 5

Power System Maintenance and Brake System Maintenance

Text: Pages 180 - 244

Learning objective: Recognize the relationship and function of power system components.

5-1. Which condition must be met before you check the air preload of a cylindrical accumulator?
1. Hydraulic and air pressures adjusted so that the piston is midway between the ports
2. Hydraulic pressure exhausted and air pressure adjusted until the piston is closer to the air port than to the fluid port
3. Air pressure exhausted
4. Hydraulic pressure exhausted

5-2. How effective is a micronic-type disposable filter?
1. It will remove 99 percent of all particles from the system
2. It will remove 90 percent of all metal particles from the system
3. It will remove 99 percent of all particles 10 microns in diameter, and larger, from the system
4. It will remove 90 percent of all particles 5 microns in diameter, and larger, from the system

5-3. Which of the following statements concerning the operation of nonbypassing filters which utilize pressure differential indicators is INCORRECT?
1. Indicator action may be bypassed under certain conditions
2. All filtering action ceases when the indicator is actuated
3. The filter element should not be periodically removed and checked
4. The more contaminated the element becomes, the greater the pressure differential developed

5-4. Refer to figure 6-24 in your textbook. Which of the following conditions will exist if the difference between inlet and outlet pressures is 100 psi?
1. Indicator button up, piston down, relief valve open, fluid flowing through filter element
2. Indicator button down, piston up, relief valve closed, fluid flowing through filter element
3. Indicator button up, piston down, relief valve closed, fluid not flowing
4. Indicator button up, piston down, relief valve open, fluid flowing but bypassing filter element

5-5. What is the maximum allowable percent of the filtration area that may be repaired on a porous metal type reusable filter element?
1. Five
2. Two
3. Three
4. Four

5-6. What two types of indicating systems are commonly used on naval aircraft to indicate hydraulic system pressure?
1. Synchro and electric
2. Direct pressure gage and bourdon
3. Direct pressure gage and synchro
4. Direct and indirect pressure gage

5-7. Refer to figure 6-26 in your textbook. What should you do if you want system pressure to reach approximately 3,250 psi before the relief valve begins to open and pass fluid?
1. Increase the distance between the adjusting nut and the poppet head
2. Decrease the distance between the adjusting nut and the poppet head
3. Increase spring tension
4. Decrease spring tension

In items 5-8 through 5-10, select from column B the component which performs the function listed in column A.

	A. Functions		B. Components
5-8.	Shuts off hydraulic pressure to systems not essential to flight	1.	Manifold
		2.	Isolation valve
5-9.	Removes the hydraulic pump load imposed on the engine during starting	3.	Pressure balanced extension unit
5-10.	Transfers fluid pressure from a fixed point to a movable point	4.	Shutoff bypass valve

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5-11. When a surge damper accumulator or surge suppressor is used, it is normally installed between the
1. reservoir and pump
2. pump and selector valve
3. selector valve and actuator
4. selector valve and reservoir

Learning Objective: Indicate the power sources used for emergency systems and recognize the operational characteristics of emergency hydraulic systems.

- Items 5-12 and 5-13 refer to the hand pump emergency power system.

5-12. What prevents system backflow during periods when the pump handle is moved?
1. Relief valve
2. Selector valve
3. Main reservoir pressure
4. Check valve

- Refer to figure 6-32 in your textbook in answering items 5-13 and 5-14.

5-13. Which of the following hand pump conditions must exist for fluid to be delivered during the aft strokes of the pump?
1. Both ball checks seated
2. Both ball checks unseated
3. Suction port ball check seated, piston ball check unseated
4. Suction port ball check unseated, piston ball check seated

5-14. Which of the following hand pump conditions requires the greatest amount of corrective action?
1. A rate of creep that equals 3 drops per hour leakage at a pressure of 2,500 psi
2. A vacuum indication of 30 inches of mercury when the pump is operated at 15 cycles per minute
3. Pump pressure decrease, piston creep
4. Pump pressure decrease, no piston creep

- Items 5-15 through 5-17 refer to the ram air turbine driven emergency system.

5-15. What is the source of the hydraulic fluid pressurized by this system?
1. The emergency system reservoir
2. The emergency system accumulator
3. The aircraft's hydraulic power control system
4. The aircraft's main hydraulic reservoir

5-16. What is the pitch position of the turbine blades when the unit is in its stowed position?
1. Low, to ensure that damaging torque is not developed when the unit is extended
2. High, to ensure that damaging torque is not developed when the unit is extended
3. High, to ensure rapid acceleration when the unit is extended
4. Low, to ensure rapid acceleration when the unit is extended

5-17. Which statement concerning the operation of the flow sensitive pressure regulator is true?
1. It functions to maintain maximum fluid output at all aircraft speeds
2. It vents excessive pressures to the reservoir of the system
3. It functions to maintain a constant fluid output at a constant pressure at aircraft speeds from 115 to 195 knots
4. It adjusts automatically to a setting that keeps the turbine from being overloaded at low speeds

Learning Objective: Identify functions and operating characteristics of emergency pneumatic power system components.

- Items 5-18 through 5-21 refer to the pneumatic power system as illustrated in figure 6-40 of your textbook.

In items 5-18 through 5-20, select from column B the component associated with the function listed in column A.

A. Functions

5-18. Ensures that the fluid to the hydraulic motor is not surging

5-19. Applies voltage to the hydraulic selector valve and the dump valve simultaneously

5-20. Enables accumulated moisture to escape from the air system

B. Components

1. Pressure sensing switch
2. Flow regulator
3. Dump valve
4. Check valve

5-21. What does the air compressor do?
1. Filters, compresses, and cools supercharged air from the engine bleed air system
2. Compresses and cools supercharged air from the engine bleed air system only
3. Filters and compresses engine bleed air and cools hydraulic motor fluid
4. Compresses supercharged air from the engine bleed air system only

5-22. How, if at all, is the compressor lubricated?
1. The entire system is splash-lubricated from oil that is in the crankcase
2. No external lubrication is required
3. It is lubricated by a system which delivers pressurized oil to a crankshaft oil passage
4. Hydraulic motor fluid is automatically delivered to the system whenever lubrication is needed

5-23. Which of these statements is a function of the moisture separator?
1. It removes bleed air from the engine through the dump valve when the pressure sensing switch is energized
2. It removes moisture from the compressor discharge whenever the oil-moisture chamber becomes two-thirds full
3. It dumps accumulated water from the compressor discharge whenever the compressor is operating
4. It removes moisture from the compressor discharge immediately after the compressor ceases to operate

5-24. Refer to table 6-3. If the solenoid in the hydraulic selector valve becomes stuck in the energized position, what will likely result?
1. The air pressure in the system will exceed safe limits
2. The dump valve solenoid will remain energized
3. The air compressor will not function
4. The air compressor will operate continuously

Learning Objective: Indicate the significance of independent aircraft braking systems, where they are used, and aspects of their operation when applied and when released.

5-25. Which type of brake system is generally used on the A-4?
1. Power control
2. Independent
3. Power boost
4. Mechanical

5-26. Power is supplied to an independent brake system by the
1. control valves
2. debooster valves
3. actuating cylinders
4. master cylinders

5-27. In an aircraft with an independent brake system, what causes the retraction of the master cylinder piston into a neutral position when the brake pedal is released?
1. Back pressure from the brake
2. A piston in the brake assembly
3. A return spring in the brake assembly
4. A return spring in the master cylinder

Learning Objective: Compare an aspect of power brake systems with independent brake, the operation of the various power brake systems with each other, and identify how A-6A aircraft brakes are applied.

In items 5-28 through 5-30, select from column B the statement which applies most to the power brake system listed in column A.

	A. Power Brake Systems		B. Statements
5-28.	True power-brake type	1.	This system uses main system pressure to regulate and release the brakes, but requires a separate emergency brake system
5-29.	Power-boost type	2.	This system operates like a true power brake under brake system pressure, but performs like an independent brake system without system pressure
5-30.	Power/manual type	3.	This system uses a master cylinder to create hydraulic pressure for braking when brake pedal pressure lowers the master cylinder piston
		4.	This system multiplies foot pedal force by applying metered amounts of main hydraulic system pressure to the braking action

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Learning Objective: In the brake system used on F-4 aircraft, identify components of the antiskid and antispin systems, preparations necessary to conduct operational and functional checks of the system, and the manner in which some of the checks are performed.

5-31. Which brake system check is performed in the same manner during both the operational checkout and the functional checkout?

1. Antiskid system
2. Brake accumulator
3. Emergency brake system
4. Wheel and tire assemblies

In items 5-32 through 5-34, select from column B the statement applicable to F-4 aircraft wheel brake system maintenance check listed in column A.

	A. Checks		B. Statements
5-32.	Running clearance	1.	Five seconds of airflow through the system, initiated by pulling the emergency brake control handle, will force any contaminants in the system to be deposited at the unplugged brake assembly pneumatic pressure port
5-33.	Brake wear	2.	The amount of wear is determined by the difference in gap size between the primary disc and the face of the screw thread insert when the brakes are released and when they are depressed
5-34.	Emergency brake system contamination	3.	Insertion of a gage into the cooling ports and depressing the brake pedals provide a measurement of the amount of wear
		4.	With external hydraulic power applied, depress the brake pedals 5 to 7 degrees to operate the lower power portion of the brake system until fluid flow is free of air bubbles

5-35. The third-stage bleeding operation is performed on the F-4 brake system to bleed the air trapped
1. in the return line
2. in the power/manual valve and the wheel brake bleed port
3. in the utility system reservoir and the power/manual valve
4. between the brake accumulator and the brake assemblies

Learning Objective: In brake system maintenance and troubleshooting, recognize the required procedure for certifying a corrected malfunction and solve troubleshooting problems.

● Refer to table 7-3 in your textbook and the following list of symptoms of troubles with wheel brake systems in answering items 5-36 through 5-39.

A. Brake action uneven with application of equal pedal pressure
B. Braking action delayed momentarily when brakes are applied
C. Brakes pull to one side
D. Steady loss of pedal pressure when brakes are applied
E. Brakes grab and chatter when pedals are fully depressed and then released slightly
F. Brake pedals not parallel with rudder in neutral and brakes released

5-36. Which of the above symptoms may be corrected by wheel brake bleeding?
1. A, D, B
2. B, C, E
3. F, D, E
4. B, D, F

5-37. If symptom A is indicated when troubleshooting, a possible cause is
1. an internal leakage in the brake control valve
2. a defective selector valve assembly
3. a leak in the brake lines
4. worn tire treads or low tire pressure

5-38. Which of the symptoms indicates the probability of a complete system rigging as the remedy?
1. A and F
2. B and E
3. C and F
4. D and E

5-39. Conducting a functional inspection is indicated by which of the following symptoms?
1. A, D, E, F
2. B, C, D, F
3. A, C, D, E
4. B, D, E, F

Learning Objective: Recognize fluid flow in aircraft braking systems, how it is regulated and how the valves that regulate it are tested and maintained.

5-40. When the reservoir of an independent brake system is being filled, the fluid displaces the air which escapes from the reservoir through the
1. vent line
2. manifold
3. expansion tube
4. filler port

5-41. If during operation of an independent brake system the hydraulic fluid becomes hot and expands, the excess volume of the fluid will escape from the reservoir through the
1. manifold
2. vent line
3. expansion tube
4. filler port

5-42. Which of the following components is used in a power brake valve to regulate the fluid to the BRAKE ports?
1. Piston
2. Plunger
3. Poppet
4. Slide

5-43. When brake pedals are fully depressed and locked in this position, what ports of the power brake valve are blocked to prevent fluid flow?
1. Return and brake ports only
2. Pressure and return ports only
3. Pressure and brake ports only
4. Pressure, return and brake ports

5-44. Maintenance of the power brake valves on the F-4 aircraft in a squadron consists of
1. removal and replacement
2. removal, disassembly, cleaning, reassembly, and reinstallation
3. removal, disassembly, cleaning, inspection, repair, and reinstallation
4. removal, disassembly, cleaning, inspection, replacement of worn parts, repair, testing, and reinstallation

5-45. Which of the following temperature conditions is NOT suitable for bench-testing a power/manual brake valve?
1. Fluid temperature 72° F, room temperature 100° F
2. Fluid temperature 105° F, room temperature 75° F
3. Fluid temperature 110° F, room temperature 70° F
4. Fluid temperature 90° F, room temperature 90° F

In items 5-46 through 5-48, select from column B the power/manual brake valve bench test performed under the condition listed in column A.

	A. Conditions		B. Bench Tests
5-46.	1,500 psi hydraulic pressure at PRESSURES port, BRAKE and RETURN ports open	1.	Leakage test, manual section
5-47.	25 psi hydraulic pressure at BRAKE port, RETURN and PRESSURE ports open	2.	Proof pressure test, manual section
5-48.	2,250 psi hydraulic pressure at BRAKE port, RETURN port plugged	3.	Proof pressure test, power section
		4.	Leakage test, power section

Learning Objective: Indicate the purpose and function of valves and miscellaneous components associated with aircraft braking systems, including some maintenance problems and restrictions and bench test procedures for the automatic brake adjuster valve.

● Items 5-49 through 5-51 refer to the following tests that must be performed in bench testing an automatic brake adjuster valve:

A. Leakage
B. Thermal crack
C. Shuttle valve closing operation
D. Shuttle valve opening operation
E. Proof pressure

5-49. In which order must these tests be performed?
1. A, D, C, E, B
2. A, C, D, B, E
3. E, B, D, C, A
4. E, D, C, B, A

5-50. When test B is performed, pressure is gradually applied to which port?
1. BRAKE port with RETURN port closed and PMV (power/manual) port open
2. BRAKE port with RETURN and PMV ports open
3. PMV port with BRAKE and RETURN ports open
4. RETURN port with BRAKE and PMV ports closed

5-51. Which test is performed with the BRAKE port blocked by a pressure gage, the RETURN port open, and hydraulic pressure gradually hand-pumped into the PMV port?
1. A
2. B
3. D
4. E

In items 5-52 through 5-54, select from column B the brake system valve to which the statement in column A applies.

	A. Statements		B. Valves
5-52.	The P-3 aircraft uses a valve of this type to direct fluid around the fuse	1.	Brake priority valve
		2.	Brake selector valve
5-53.	This valve regulates pressure to the brake assembly to stop wheel rotation on takeoff when landing gear retraction is initiated	3.	Brake in-flight pressure regulator valve
		4.	Brake bypass valve
5-54.	As part of the auxiliary brake system, this valve assures the retention of sufficient accumulator pressure for four full emergency applications of the brakes when they must be manually activated		

In items 5-55 through 5-57, select from column B the purpose of the brake system valve listed in column A.

A. Valves

5-55. Landing gear selector and brake shutoff valve

5-56. Emergency brake actuating valve

5-57. Thermal relief valve

B. Purposes

1. Provides for releasing emergency air to the brakes for several applications on aircraft with separate air emergency braking system
2. Closes the pressure inlet lines to the power brake valve during landing gear retraction
3. Relieves pressure expansion caused by high temperature buildups resulting from excessive use of brakes
4. Controls fluid flow to activate the brake action selected by the pilot

In items 5-58 through 5-60, select from column B the brake system miscellaneous component applicable to the function identified in column A.

A. Functions

5-58. Prevents the complete loss of hydraulic fluid in the accumulator if a leak occurs in the brake cycles gage or the line going to it

5-59. Permits fluid to flow freely in one direction in a hydraulic line, but acts to prevent the reversal of the fluid flow, even under differing pressures

5-60. Provides an emergency source of pressure to operate an aircraft's brakes if the normal system fails

B. Components

1. Swivels
2. Accumulators
3. Fuses
4. Check valves

Learning Objective: Recognize the purpose and operational characteristics of skid control systems in aircraft braking systems.

5-61. Which statement about the operation of the skid control system during a skid is FALSE?

1. Braking is prevented until after touchdown by the steering weight-on-wheels switch and the wheel sensing circuit in the antiskid control box
2. The weight-on-wheels switch, when compressed by the aircraft's weight, functions to deenergize the locked wheels sensing circuit
3. The antiskid control box applies electrical signals to the antiskid control valve to control skids before they occur
4. The skid control valves are energized to the OPEN position until the first application of brake pressures

5-62. To avoid a skid condition during the landing of an aircraft, brake pressure will be prevented from entering the brake lines until

1. excessive brake pressure restricts wheel rotation
2. the main wheels rotate to rearm the antiskid detectors
3. the skid control valves are closed
4. the brake line pressure is released to the hydraulic system return line through the back-pressure restrictor

5-63. Refer to figure 7-21 in your textbook. When both the upper and lower pilot valves have been energized to release brake pressure and reduce spring force simultaneously, the antiskid control valve is in which operating condition?

1. Normal operation
2. Metering release
3. Rapid release
4. Pressure reapplication

Assignment 6

Brake System and Landing Gear Maintenance

Text: Pages 248-299

Learning Objective: Identify components, maintenance, and testing procedures associated with single-, dual-, and multiple-disc brake assemblies incorporating automatic self-adjustment features.

6-1. What prevents the piston from returning to its original position when the brakes are released in a brake system with the self-adjustment feature?
1. Spring guide
2. Return spring
3. Adjustment pin
4. Automatic adjusting nut

6-2. To capture the adjusting pin when the brakes are released, the captured torquing-type automatic brake adjuster uses friction between the
1. tapered pin grip and the adjusting pin
2. piston and the face of the adjusting pin
3. brass lined pin grip and the adjusting pin
4. piston and the adjusting pin spring guide

6-3. Which of the following statements concerning single-disc brake maintenance is false?
1. Brake repairs consist of replacing linings, worn or damaged sealing devices, and brake release units, or discs
2. If examination reveals nicks or gouges in a brake release unit, the complete unit must be replaced
3. Prior to installation, brake release unit packings from the cure-date kit must be coated with hydraulic fluid
4. Automatic adjusting nuts should be torqued to the specified value once and not retorqued

6-4. You have replaced the seals and are ready to test single-disc brakes. Connect the brake assembly to a hydraulic supply source, bleed the brake assembly, and then apply
1. 100 psi for 6 minutes
2. 200 psi for 6 minutes
3. 600 psi for 2 minutes
4. 600 psi for 1 minute

6-5. In the multiple-disc brake system used on the RA-5C aircraft, the running clearance of the wheel depends on adjustment of the
1. retracting springs
2. backup plate retainer
3. pressure plate
4. rotors and stators in the heat stack

6-6. In a multiple-disc brake, the backup plate will not rotate more than a fraction of an inch when you pull out on the retainer and turn. What do you do now?
1. Back off the locking piece bolt to the next position
2. Make sure that the backup plate engages the splined torque sleeve
3. Realize that the job was done right
4. Start all over with the backup plate

In items 6-7 through 6-9, select from column B the dimension that indicates the acceptability of the multiple-disc brake system heat stack component listed in column A.

	A. Components	B. Dimensions
6-7.	Distance across retractor plate from outboard edge to splined torque sleeve	1. 0.025 inch average
		2. From 3 29/32 to 4.0 inches
6-8.	Thickness of heat stack from torque sleeve to backup plate	3. 3/8 inch from edge
6-9.	Thickness of rotor lining material	4. 1/8 inch minimum

6-10. What is used to clean and dry the parts of the multiple-disc brake assembly during intermediate maintenance?

1. Stoddard Solvent, low-pressure air
2. Light grade machine oil, lint-free cloth
3. Hydraulic fluid, felt-wiping cloth
4. Petrolatum, high-pressure air

6-11. Before the completely reassembled multiple-disc brake assembly can be tested for leakage after intermediate maintenance, it must be bled

1. through the bleeder valves using 3,000 psi hydraulic pressure
2. from underneath the retainer plate using 200 psi hydraulic pressure
3. through the bleeder valves using 200 psi hydraulic pressure
4. from underneath the retainer plate using 3,000 psi hydraulic pressure

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Learning Objective: In the tri-metallic brake assembly, indicate component functions, operation, and associated maintenance practices.

In items 6-12 through 6-14, select from column B the tri-metallic brake assembly component that performs the function listed in column A.

	A. Functions		B. Components
6-12.	Transmits hydraulic pressure through the pressure plate subassembly to the brake discs	1.	Metallic-faced rotating disc
6-13.	Passes the force between the brake pistons and the brake discs during application and release of brakes	2.	Pressure plate subassembly
6-14.	Releases brakes under normal conditions and compensates for brake lining wear	3.	Brake pistons
		4.	Self-adjusting mechanism

In items 6-15 through 6-17, select from column B the operation of the tri-metallic brake assembly that is performed by the component in column A.

	A. Components		B. Operations
6-15.	Brake pistons	1.	Forces the entire pressure plate subassembly laterally against the discs and against the housing back plate
6-16.	Return spring mechanism	2.	Pulls the self-adjusting pins as it moves laterally against the discs and housing back plate to brake the aircraft
6-17.	Pressure plate subassembly	3.	Pulls the pressure plate subassembly back to the released position as decreasing hydraulic pressure allows expansion from the fully compressed position
		4.	Limits the extent of the return motion of the pressure plate subassembly as hydraulic pressure is decreasing and the return springs expand

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Learning Objective: Identify components of the segmented rotor brake assembly, their location and function, and recognize expander tube-type brake operation and maintenance.

In items 6-18 through 6-20, select from column B the component of a segmented rotor brake assembly which performs the function listed in column A.

	A. Functions	B. Components
6-18.	To receive the ultimate hydraulic force resulting from brake application	1. Carrier 2. Stator plate
6-19.	To absorb and transmit all brake torque to the strut brake flange	3. Backing plate 4. Pressure plate
6-20.	To transmit the axial clamping force from the actuating piston to the brake disc elements	

6-21. Which of the following statements about the expander tube-type brake is true?
1. This system operates on high-pressure air
2. This type brake applies 360° of braking surface to the drum
3. The two wheel halves of this system are factory balanced and the heavy area is stamped with the letter "H"
4. When the drums in this system are installed, they are placed so that their "H" stamp is opposite the "H" stamp on the respective wheel half

6-22. What is the maintenance problem with the expander tube brake drum that requires immediate replacement of the drum?
1. Transverse shrinkage
2. Circumferential shrinkage
3. Heat cracks through the cast iron to the steel
4. Imbalance from uneven wear

Learning Objective: Recognize operating characteristics, component functions, and maintenance responsibilities of AMH personnel for both normal and emergency landing gear systems, and indicate factors considered in selecting emergency extension methods.

6-23. During taxiing and braking, the loads and the weight of the T-39 aircraft are carried mainly by the
1. air in the inner cylinder assembly of the recoil strut
2. air in the outer cylinder assembly of the recoil strut
3. fluid metered through the orifice of the outer cylinder in the recoil strut
4. stability augmentation balance weight of the recoil strut

6-24. Refer to figure 8-2 in your textbook. When the nose gear is retracted, what component closes the nose gear uplock hook after the uplock roller passes the lip of the hook?
1. The gear strut cam
2. The tension-regulating bungee
3. The uplock actuating cylinder
4. The return spring

6-25. The main gear and strut fairing doors are unlocked by
1. pneumatic pressure applied to the over-center lock mechanism
2. electrical power applied to the switches attached to the wheel fairing doors
3. hydraulic pressure applied to the main gear uplock hook actuating cylinders
4. the cable attached to the uplock hooks

6-26. What component protects the gas generator chamber of the transmitter from overpressurization?
1. The relief valve
2. The burst-type diaphragm
3. The check valve
4. The blowout disc

6-27. Which of the following statements relative to the T-39D emergency extension system is false?
1. The landing gear electrical reset switch must be reset after an emergency extension before the landing gear can be retracted
2. The main gear is extended and locked by gravity with the aid of the bungee
3. The nose gear is extended and locked by the airstream during flight
4. The nose gear is extended and locked by gravity and the main landing gear is forced down and locked by the airstream during flight

6-28. Which of the following statements relative to the emergency operation of the A-7 aircraft landing gear is false?

1. The control handle must be in the emergency wheels down position before the selector valve opens and directs emergency pressure to the shuttle valves on the nose and main gear door actuators
2. The leaf spring assembly is capable of forcing the nose gear to the down-and-locked position
3. The emergency bypass valve isolates the emergency return fluid from the normal landing gear return circuit
4. The landing gear system is automatically returned to normal system configuration when hydraulic pressure is applied and the system cycled twice

6-29. The primary responsibilities of senior AMH personnel in landing gear maintenance include all of the following EXCEPT the

1. evaluation of landing gear damage
2. supervision of drop checks
3. fabrication of rigid and flexible plumbing
4. training of subordinates in the correct maintenance procedures

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Learning Objective: Recognize requirements for making landing gear drop checks, and indicate related operational and jacking procedures.

6-30. How much hydraulic pressure is required before the gear assemblies begin to retract?

1. 1,800 psi
2. 2,550 psi
3. 3,000 psi
4. 3,500 psi

6-31. In the performance of the drop check of the landing gear, the system is operating properly if the gear retracts and extends in

1. 5 to 7 seconds
2. 8 to 10 seconds
3. 12 to 14 seconds
4. 15 to 18 seconds

6-32. When checking the emergency extension of the landing gear, you may have to manually push the main gear assemblies to the down-and-locked position. What is the maximum force that should be required?

1. 10 pounds
2. 20 pounds
3. 30 pounds
4. 40 pounds

6-33. Where are the jacking receptacles of an aircraft with tricycle landing gear?

1. Main receptacles on each wing, at the nose, and at the tail
2. Main receptacles on each wing, and a stabilizing receptacle at the nose
3. Main receptacles on each wing and the tail, and a stabilizing receptacle at the nose
4. Main receptacles on each wing and the nose, and a stabilizing receptacle at the tail

6-34. Where are the men located to jack an aircraft with a tail wheel landing gear?

1. One at each main jack, and one at the stabilizer jack
2. One at each wing jack, one at the nose jack, one at the tail jack, and one in front of the aircraft
3. One at each wing jack, one at the tail jack, and one in front of the aircraft
4. One at each wing jack, one at the nose jack, and one in front of the aircraft

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In items 6-35 through 6-37, select from column B the action necessary during the aircraft jacking operation to effect the result listed in column A.

	A. Results	B. Actions
6-35.	The aircraft is raised evenly at all points	1. The aircraft must be kept as level as possible
6-36.	The aircraft does not fall if jack fluid loss occurs	2. The tiedown equipment must be installed
6-37.	The jack points are not overloaded	3. The collar on the jacks must be turned down progressively
		4. The jacks must be operated simultaneously

6-38. Prior to jacking an aircraft aboard ship, the senior AMH who will supervise the operation must receive authorization from

1. material control
2. maintenance/production control
3. quality assurance
4. the aircraft division

Learning Objective: Recognize troubleshooting practices for landing gear systems, personnel responsible for verifying completed steps of newly installed landing gear assemblies, and landing gear alignment check procedures/damage evaluation.

6-39. Which of the following statements relative to troubleshooting landing gear systems is false?
1. The Maintenance Instructions Manuals contain procedures to follow in isolating malfunctions
2. System schematics and maintenance instructions should be used, when necessary, to determine the causes of malfunctions
3. A trouble which is detected during the checkout procedure should be corrected after the checkout is accomplished
4. Discrepancies which occur in flight often require thorough checking of the system to locate malfunctions

6-40. Who has the responsibility for verifying designated steps in the alignment of newly installed landing gear assemblies prior to the next step?
1. The crewleader
2. The work center supervisor
3. The quality assurance representative
4. The maintenance control representative

6-41. Which of the following damaged areas is the most critical?
1. Buckled fuselage skin
2. Doors jammed
3. Bolt hole elongation
4. Nose gear sheared

Learning Objective: Recognize operating principles of recoil struts and their components.

6-42. What component counteracts the bouncing motion of the recoil struts when the landing shock load is applied to the strut?
1. The upper steering arm
2. The recoil valve
3. The piston head
4. The metering pin

6-43. Refer to figure 8-4 in your textbook. Which event occurs just before the recoil valve seats on the piston head?
1. The tapered metering pin closes the orifice in the piston
2. The hydraulic fluid flows through the 16 holes in the piston head
3. The follower moves downward as the strut extends
4. The hydraulic fluid is forced out of the cylinder chamber

6-44. The A-6A nose strut is prevented from becoming completely rigid after the throttles are forward and the catapult grip rotated to the catapult position for takeoff by the
1. hydraulic fluid passing through the 16 holes in the piston head and the nitrogen trapped in the orifice holes in the upper tube
2. four orifices in the upper tube not being completely sealed
3. three radial openings in the orifices being sealed as the upper tube bottoms on the lower tube
4. nitrogen in the upper cylinder being partly discharged to prevent excessive pressure between the upper and lower cylinders

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Learning Objective: Recognize forces which act on the P-3C main loading gear upon runway contact, characteristics of the P-3C landing gear, and the maintenance and servicing procedures of the main gear recoil struts.

6-45. Which statement relative to the P-3C soft strut landing gear is false?
1. The nitrogen precharge pressure is only 20 percent as effective as the standard strut
2. The precharge pressure does not increase significantly during dampening
3. The initial 3.5 inches travel of the oleo piston reduces the tire friction on the runway during landing
4. The strut was modified for use on lighter weight aircraft

6-46. Which step should you take first when replacing the piston O-rings in the main gear recoil strut?
1. Remove the up and down lines from the gear actuating cylinder
2. Release the spring tension on the gear down lock mechanism
3. Cap all loose lines and fittings to prevent contamination
4. Release the nitrogen pressure through the strut filler valve

6-47. After the strut cylinder is partially retracted, you should remove the
1. piston head pins
2. gland nut
3. metering pin assembly
4. thrust bearing assembly

6-48. To remove minor scratches from steel surfaces of recoil strut components, you should use
1. a second-cut file
2. crocus cloth
3. an aluminum-oxide abrasive cloth
4. a fine-grade sandpaper

6-49. Which statement relative to servicing the recoil strut after assembly is false?
1. The brakes should be bled
2. The lower strut linkage should be lubricated
3. The outer surface of the piston and the inner surface of the cylinder should be coated with hydraulic fluid
4. The landing gear system should be tested

6-50. After an aircraft with split rim wheels has been jacked, the first thing that you should do in preparation for removal of the recoil struts is to
1. deflate the tires
2. remove the wheels
3. remove the fairings and door connecting rods
4. disconnect the electrical connections at the cannon plugs

6-51. When you remove a recoil strut from an aircraft, which of the following is removed with the strut assembly?
1. Drag brace
2. Shrink rod
3. Side brace
4. Wheel assembly

Learning Objective: Recognize recoil strut repair which may be accomplished at intermediate level maintenance activities, and indicate procedures followed in cleaning, inspecting, and maintaining strut assemblies.

6-52. What is the first step in the disassembly of a recoil strut?
1. Drain the hydraulic fluid
2. Disconnect the torque arms
3. Exhaust all the air from the strut
4. Withdraw the inner cylinder from the outer cylinder

6-53. When cleaning the recoil strut assembly and associated components, AMHs should do all of the following EXCEPT
1. wipe the lower bearing with a lint-free cloth dampened with hydraulic fluid
2. coat the cleaned parts with hydraulic fluid if they normally come in contact with the fluid
3. spray cleaning solvent P-D-680 on the strut assembly, then dry the strut with compressed air
4. clean bearings with cleaning solvent, then dry them with compressed air

6-54. In bench testing a strut, what is the time interval that must elapse before checking it for leaks?
1. 1 hour
2. 2 hours
3. 3 hours
4. 1/2 hour

6-55. How is the nosewheel steering system illustrated in figure 8-7 in your textbook controlled and actuated?
1. Manually controlled, electrically actuated
2. Cable controlled, hydraulically actuated
3. Hydraulically controlled, cable actuated
4. Electrically controlled, hydraulically actuated

Learning Objective: Identify operating principles/features of the A-7E electrically controlled nose steering system, functions of associated components, and related maintenance procedures.

6-56. Which of the following statements relative to the electrical power applied to the steering system is false?
1. When the system is engaged the nose gear remains centered until the rudder pedals are deflected
2. The steering selector valve supplies hydraulic pressure to the steering cylinder servo valve
3. The secondary ac power energizes the weight-off-gear relay to provide a control signal to the input transducer primary coil
4. The steering selector valve is energized by dc power applied through closed contacts of the steering cutout switch

6-57. What is the sequence of events in the servocontrol loop when the rudder pedal is deflected for a right turn?
1. Steering amplifier provides proportional ac input signals → transducers provide proportional dc signals → cylinder servo valve ports hydraulic fluid to cylinder piston to turn nose gear
2. Transducers provide proportional ac input signals → steering amplifier provides proportional dc signals → cylinder servo valve ports hydraulic fluid to cylinder piston to turn nose gear
3. Transducers provide proportional ac input singals → steering amplifier provides proportional ac signals → cylinder servo valve ports hydraulic fluid to cylinder piston to turn nose gear
4. Steering amplifier provides proportional dc input signals → transducers provide proportional dc signals → cylinder servo valve ports hydraulic fluid to cylinder piston to turn nose gear

6-58. What provides the servocontrol loop with 400-Hz ac input signals proportional to the nose gear displacement from the centered position?
1. Followup transducer and steering amplifier
2. Steering amplifier and cylinder servo valve
3. Input and followup transducers
4. Cylinder servo valve and input transducer

6-59. Dampening of the nose gear will occur when the steering
1. cylinder servo valve is energized
2. cutout switch closes
3. angle is less than 61 degrees
4. angle exceeds 61 degrees

6-60. Erratic forces acting on the nose gear are dampened by the
1. cylinder servo valve
2. relief valve
3. damper shutoff valve
4. dump valve

6-61. When you perform an operational check of the nose gear, at what angular position should you manually place the gear?
1. 35 degrees plus 0.1 inch
2. 46 degrees plus 0.2 inch
3. 58 degrees plus 0.4 inch
4. 61 degrees plus 0.3 inch

6-62. Which of the following actions relative to bleeding the nose gear is false?
1. You should use an external electrical power source to operate the controls
2. You should bleed the system any time a component is replaced
3. You should retract the gear using only the aircraft's hydraulic system
4. You should bleed the system until a steady stream of hydraulic fluid is observed free of air

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Learning Objective: Recognize operating characteristics of the mechanically controlled A-6A nose steering system, including pertinent maintenance data.

6-63. The steering system of the A-7E differs from the A-6A in that the former is electrically controlled and the latter is
1. hydraulically controlled
2. mechanically controlled
3. manually controlled
4. pneumatically controlled

6-64. If the 28-volt dc bus is energized and combined pressure is available, under which of the following conditions is the steering mechanism pressurized automatically?
1. The arresting hook is down and weight is on the aircraft's wheels
2. The steering switch on the pilot's stick grip is depressed
3. The steering system is automatically pressurized when either 1 or 2 above occurs
4. The secondary dc, the secondary ac, and the 26-volt primary ac instrument buses are energized

6-65. How much torque in inch-pounds is required on the rudder pedal to produce a minimum output torque of 12,000 inch-pounds?
1. 5
2. 10
3. 25
4. 30

6-66. Disassembled parts of a steering damper should be cleaned with
1. aliphatic naphtha
2. aromatic naphtha
3. drycleaning solvent
4. trichlorethylene

Learning Objective: Indicate operating characteristics and maintenance practices applicable to the nose landing gear catapult launching equipment.

6-67. Which event occurs just before the aircraft is catapulted off the deck?
1. The selector is deenergized
2. The catapult shuttle engages
3. The tension bar breaks
4. The launch bar actuator rod extends

6-68. If the automatic hydraulic retraction fails, what force do the leaf springs provide to retract the launch bar?
1. 50 pounds
2. 80 pounds
3. 100 pounds
4. 150 pounds

6-69. After a hard catapult launching is reported, what maintenance is required?
1. Rigging the launch bar actuator
2. Troubleshooting the catapult launching system
3. Inspecting in accordance with the Maintenance Requirements Cards
4. Lubricating the shuttle bearing surfaces

6-70. The load-bearing components of a catapult system should NOT be used in excess of
1. 1,500 launches
2. 1,800 launches
3. 2,000 launches
4. 2,500 launches

Assignment 7

Landing Gear Maintenance and Flight Control System Maintenance

Text: Pages 300-355

Learning Objective: Recognize operational characteristics of the arresting gear system, identify a source which provides information pertaining to the inspection, replacement, and disposition of arresting hook assemblies, and recognize the types of arresting hooks.

7-1. What limits the extension of the arresting hook?
1. The travel of the piston in the bumper actuating assembly
2. The distance the arresting gear control handle is pulled
3. The travel of the piston in the snubber-actuator
4. The distance the bumper mechanism is moved

7-2. The arresting hook is directly retracted by the action of the
1. bumper
2. accumulator
3. control valve
4. snubber-actuator

7-3. If the arresting gear selector valve becomes stuck in the retract position, extension of the hook is provided by which of the following?
1. Override bungee
2. Priority bypass line
3. Mechanical override linkage
4. All of the above

7-4. If the arresting hook control cable breaks, what is provided for uplock hook operation?
1. An emergency accumulator
2. A solenoid
3. An override bungee
4. A priority bypass line

7-5. Refer to figure 8-14 in your textbook. Which of the following is the cause of arresting hook retraction?
1. Gravity only
2. Hydraulic pressure
3. Accumulator pressure only
4. The combined action of accumulator pressure and gravity

7-6. Which of the doors that fair the hook assembly into the fuselage are actuated by link rods attached to the hook assembly?
1. Trunnion doors
2. Hook point doors
3. Beam fairing and trunnion doors
4. Hook point and beam fairing doors

7-7. Detailed information pertinent to the inspection, replacement, and disposition of arresting hook assemblies is provided in the
1. Maintenance Instructions Manual
2. Structural Hardware Manual
3. Structural Repair Manual
4. Periodic Maintenance Information Cards

In items 7-8 and 7-9, select from column B the type of arresting hook which is associated with the description listed in column A.

	A. Descriptions	B. Types of Arresting Hooks
7-8.	Metco coated hook point	1. I
		2. II
7-9.	Highly heat treated with an uncoated hook point	3. III

Learning Objective: Recognize adjustments and functions of components of the single shank-type arresting gear hook assembly and the compressibility and operating pressure of the liquid spring.

7-10. What component prevents side movement of the arresting hook during carrier arrested approaches?

1. The shank
2. The index arm
3. The drag link
4. The liquid spring

7-11. If side play of the hook point exceeds 0.24 inch, shims must be added to the

1. shank
2. index arm
3. liquid spring
4. drag link

7-12. The compressibility of the overall liquid spring assembly is

1. 0.125 inch
2. 0.24 inch
3. 0.68 inch
4. 0.76 inch

7-13. What will be the approximate operating pressure within the spring assembly when bottomed out?

1. 20,000 psi
2. 10,000 psi
3. 7,500 psi
4. 5,000 psi

7-14. Which of the following steps should you take first when adjusting the centering springs?

1. Tighten the nuts on the attaching bolts fingertight
2. Adjust the rod ends of both centering springs
3. Torque the rod end jamnut to 270-300 inch-pounds
4. Safety the attaching bolts with cotter pins

Learning Objective: Identify primary flight control surfaces which are hydraulically operated and the number of hydraulic systems required in Navy aircraft.

7-15. In a full power-operated system, which of the following aircraft primary flight control surfaces are operated by hydraulic pressure?

1. Rudder and ailerons only
2. Elevators and rudder only
3. Ailerons, rudder, and trim tabs
4. Ailerons, elevators, and rudder

7-16. Current specifications require that the primary flight control surfaces of naval aircraft be capable of being operated from how many different hydraulic systems?

1. One
2. Two
3. Three
4. Four

7-17. Refer to figure 9-1 in your textbook. Which of the following is descriptive of the sequence of actions that would result in the aircraft's right aileron being moved to its up position?

1. Mechanical/hydraulic/mechanical
2. Mechanical/electrical/hydraulic
3. Hydraulic/pneumatic
4. Mechanical/pneumatic

7-18. If there is a complete hydraulic system failure, how may the power mechanism cylinder and the load feel bungee be disconnected from the aileron control system to reduce system load?

1. Electrically
2. Pneumatically
3. Hydraulically
4. Manually

7-19. The flutter damper functions to reduce aileron flutter by

1. increasing fluid flow between the chambers
2. limiting fluid flow between the chambers
3. maintaining identical fluid pressure in all the chambers
4. performing any of the above, depending on system demands

Learning Objective: Identify the components, control methods, and power sources of the A-6 flaperon system, and recognize the significance of the combination spoiler/deflector system used on the A-7, its components and component tasks.

7-20. The A-6 flaperon system consists of

1. two actuators, two inboard flaperons, and two outboard flaperons
2. three actuators, two inboard flaperons, and two outboard flaperons
3. four actuators and two flaperons
4. four actuators and four flaperons

7-21. The eddy current damper in the A-6 flaperon system functions to create a force that
1. assists the side-to-side movement of the control stick
2. assists the fore and aft movement of the control stick
3. opposes side-to-side movement of the control stick
4. opposes the fore and aft movement of the control stick

7-22. What inflight capability of the A-7 aircraft is enhanced by the aileron and spoiler/deflector arrangement?
1. Control during high speed turns
2. Roll rate around lateral axis of the aircraft
3. Roll rate around longitudinal axis of the aircraft
4. Control in dives

In items 7-23 through 7-25, relative to the A-7 aileron and spoiler/deflector arrangement, select from column B the task which applies to its component in column A.

A. Components

7-23. Load limiting link

7-24. Viscous damper cylinder

7-25. Mechanical feel spring assembly

B. Tasks

1. Prevents overcontrol of stick movement when Control Augmentation mode is engaged

2. Protects control linkage from damage caused by excessive loads

3. Provides artificial feel to the control stick

4. Prevents excessive forces from reaching the control stick

Learning Objective: Relative to longitudinal control systems, recognize the application and control of bobweights in the A-4 elevator system and the characteristics and operation of the A-6 horizontal stabilizer.

7-26. When the A-4 performs a series of climbs and dives, the function of the bobweights in the elevator control system is to
1. reduce control stick load
2. reduce push-pull tube vibration
3. help the pilot in displacing the stick from its neutral position
4. help place the control stick in its neutral position

7-27. The elevator control system viscous damper functions to
1. speed up bobweight movement
2. slow down bobweight movement
3. cause the forward and aft bobweights to move at the same rate
4. stabilize push-pull tube movement

7-28. Which of the following conditions could be caused by a disconnected elevator load spring?
1. Balanced forward and aft bobweights when the elevators are in their neutral positions
2. Unbalanced forward and aft bobweights when the elevators are in their neutral positions
3. Unbalanced elevators not capable of being moved from their full up to their full down positions
4. Lost elevator system damper capability

7-29. How is the need for greater aircraft control at lower airspeeds accommodated by the A-6 horizontal stabilizer?
1. Additional 14 degrees leading edge down capability is provided in dirty configuration
2. Additional 14 degrees leading edge up capability is provided in dirty configuration
3. Leading edge down can be reduced by 10 degrees in dirty configuration
4. Leading edge up can be reduced by 10 degrees in dirty configuration

7-30. Which of the following statements about the A-6 horizontal stabilizer control system is true?
1. The stabilizer actuator is a tandem-type actuator powered by both flight and combined system pressures and operates in manual, series, or parallel modes
2. When the integrated position indicator STAB window shows a picture of a stabilizer, the horizontal stabilizer is in the clean configuration
3. The pilot input alone controls the power valve when the actuator is in the series mode
4. Setting the actuator in the manual mode combines pilot input with AFCS input signals to control the power valve

7-31. How is manual input to the A-6 horizontal stablizer control system blocked when the parallel mode has been actuated?
1. The linear transducer, mounted on the servo ram centerline, provides electrical signals to block the series mode solenoid valve
2. The series mode solenoid is deenergized when the parallel mode solenoid is actuated
3. Flight system fluid pressure stabilizes the lockout piston and holds the mechanical input at neutral
4. Mechanical input is locked out at the mode selector by the pilot

Learning Objective: Recognize characteristics, components, and operation of the A-5 vertical stabilization system.

In items 7-32 through 7-36, select from column B the A-5 vertical stabilizer system fuselage mechanism/group for the component in column A.

	A. Components		B. Mechanisms/Groups
7-32.	Fore-and-aft cables	1.	Forward fuselage mechanism
7-33.	Yaw trim actuator	2.	Intermediate fuselage mechanism
7-34.	Rudder pedals	3.	Aft fuselage group
7-35.	Vertical stabilizer actuator		
7-36.	Step-up mechanism		

7-37. At what point in the sequence of events leading to the mechanical actuation of the A-5 vertical stabilizer is hydraulic pressure introduced?
1. In the forward fuselage mechanism following the transmittal of force from either rudder pedal to the pedal adjuster actuator
2. In the intermediate fuselage mechanism to assist the step-up to the ratio changer assembly
3. In the aft fuselage group to actuate the ratio changer when vertical stabilizer movement must be restricted because of retracted flaps
4. In the aft fuselage group following displacement of the surface actuator valve rod

Learning Objective: Introduce the F-14 flight control systems, and identify changes from the control systems of earlier naval aircraft.

7-38. The F-14 stabilizer effects aircraft movement about the
1. roll axis only
2. yaw only
3. pitch only
4. roll and pitch axes

7-39. The spoilers on the F-14 aircraft can only be operated when the wings are swept forward of
1. 27 degrees
2. 37 degrees
3. 47 degrees
4. 57 degrees

7-40. Rotating the thumbwheel control on the control stick grip to the fully aft position causes the spoilers and stabilizers to assume what position?
1. Extends the spoilers 12°, moves the stabilizers to 8° trailing edge down
2. Retracts the spoilers -4.5°, moves the stabilizers to 0°
3. Extends the spoilers -4.5°, moves the stabilizers to 8° trailing edge up
4. Retracts the spoilers to 0°, moves the stabilizers to 0°

7-41. What unit in the wing sweep control system prevents wing mispositioning?
1. Synchronizing shaft
2. Flow divider
3. Air-data computer
4. Sweep control box

7-42. Minimum wing sweep limiting is NOT available under which method of wing sweep control?
1. Electronic
2. Mechanical
3. Automatic
4. Bomb manual

Learning Objective: Relate given aircraft directional control surface maintenance problems with inspections, troubleshooting, probable causes, and testing, and identify appropriate maintenance levels and component disposition.

7-43. Relative to the maintenance of directional control surface power actuators, which statement is true?
1. Linkage removal starts at the aileron and progresses to the aileron power mechanism
2. Two or more components must be replaced before a rigging verification is required
3. A power actuator which causes flight system malfunction must be forwarded to the supply activity for disposition
4. A power mechanism may be repaired at the organizational maintenance activity level

7-44. What is to be done with a hydraulic component removed because of a malfunction?
1. Repair it locally
2. Preserve and turn it in for evaluation and repair
3. Disassemble, clean, reassemble, and turn it in for repair
4. Retain its as-is condition and turn it in for evaluation

7-45. Quality assurance is a must during which stage(s) of repair?
1. Before each step of repair
2. After each repair step
3. During the final test
4. Throughout the repair procedure

7-46. Identify a possible cause of sluggish control surface travel.
1. Freely rotating pushrods, bellcranks, and idlers
2. High cable tension
3. Low cable tension
4. Broken cable strands

Learning Objective: Relative to secondary flight controls, recognize the characteristics, operation, and selected component functions of a typical wing flap system, leading edge/trailing edge flap arrangements typified by the F-4, and semi-independent flap and slat systems typified by the A-6, and identify some aspects of A-6 flap and slat system maintenance.

7-47. How is a wing flap system controlled and actuated?
1. It is mechanically controlled and hydraulically actuated during normal operation and hydraulically controlled and mechanically actuated during emergency operation
2. It is mechanically controlled and hydraulically actuated during both normal and emergency operations
3. It is mechanically controlled and operated during all operating conditions
4. It is hydraulically controlled and operated during all operating conditions

7-48. When the wing flap handle is moved from neutral to its full down position, what repositions the selector valve to its neutral position?
1. Spring-loaded followup pushrod
2. Cylinder piston rod
3. Right flap pushrod
4. Left flap pushrod

7-49. What condition ensures that the wing flaps will be locked when in the full up position?
1. The flap control handle being in its detent position
2. Spring pressure being exerted by the followup pushrod
3. The selector valve being slightly displaced from neutral
4. The selector valve being in neutral

7-50. What is the main purpose of the wing flap retraction shutoff valve?
1. To provide a bypass for pressurized fluid so that the flaps lower rapidly
2. To provide a bypass for return fluid so that the flaps can retract rapidly
3. To allow the flaps to be locked at any position between full up and full down
4. To allow the 1,500-psi system pressure to be rapidly removed from the wing flap selector valve

7-51. How many leading-edge and trailing-edge flap panels are in the F-4 secondary flight control system?
1. 2 leading and 6 trailing
2. 3 leading and 2 trailing
3. 6 leading and 2 trailing
4. 8 leading and 3 trailing

7-52. What controls the actuation of the wing flaps in the F-4 secondary flight control system?

1. A 3-position switch labeled UP, 1/2, and DN
2. Manifold-mounted selector valves
3. Dual actuating cylinders
4. Wing-mounted dual-tandem actuating cylinders

7-53. In the operation of the F-4 leading edge wing flaps, if the flap control switch is placed in the 1/2 position, utility system pressure is directed by the manifold-mounted selector valve to the

1. down lines and causes leading edge flaps to lower to 1/2 down position
2. up lines and causes leading edge flaps to rise to 1/2 up position
3. down lines and causes leading edge flaps to lower to full down
4. up lines and causes leading edge flaps to rise to full up

7-54. When the F-4 leading edge wing flaps are in the full down position and the trailing edge flaps are in the 1/2 position, in what position is the flap control switch?

1. UP
2. DN
3. 1/2
4. Neutral

7-55. In the F-4 wing flap control system, when all flap actuators have been directed to the retract side and the electrical control circuits and solenoids of both selector valves are deenergized, what will be shown in the cockpit flap position indicator?

1. DN
2. UP
3. 1/2
4. Barber poles

7-56. On a late model F-4 aircraft, the emergency flap system has been actuated and the aileron drooping feature does not operate. Which conclusion to draw from these conditions?

1. Return hydraulic fluid has been dumped overboard
2. Either the wing flap selector is not positioned at DN or 1/2 or emergency air pressure has not repositioned the flap system dump valve
3. The mechanical linkage between the emergency flap control handle and the emergency flap air selector is inoperative
4. The drooping aileron feature does not function in emergencies

7-57. A unique feature of the A-6 wing flap system is that in emergencies the type of power to drive the eight flap actuators changes from

1. electric to hydraulic
2. hydraulic to electric
3. hydraulic to pneumatic
4. pneumatic to electric

- Refer to these operational sequences in A-6 wing flap operation in answering items 7-58 through 7-62:

A. Electrical circuit completed through 30-degree switch and gearbox limit switch to selector valve → pressure ported to down side of highspeed hydraulic motor to drive gearbox → gearbox drives all eight flap actuators → flap actuators drive flaps out and down to 30-degree position.

B. Electrical circuit completed through closed 40-degree down limit switch in gearbox to selector valve → pressure ported to down side of highspeed hydraulic motor drives gearbox → gearbox drives all eight flap actuators → flap actuators drive flaps out and down to 40 degrees → 40-degree limit switch breaks electrical circuit to halt flap travel.

C. Electrical circuit completed through 30-degree switch and gearbox limit switch to selector valve → pressure ported to retract side of highspeed hydraulic motor to drive gearbox → gearbox drive flap actuators to retract flaps to full up position.

D. Flap hydraulic brake valve energized → pressure removed from spring-loaded hydraulic motor brake → brake locks motor and input shaft → electric motor drives flap gearbox to place flaps in 40-degree down position.

7-58. Operational sequence A occurs when the flap control handle is positioned in

1. UP
2. EMERG
3. TAKEOFF
4. LAND

7-59. Which operational control sequence takes place when the flap control handle is in LAND?

1. A
2. B
3. C
4. D

7-60. Which of the operational sequences applies after both takeoff and landing?
1. A
2. B
3. C
4. D

7-61. Which operational sequence governs an emergency?
1. A
2. B
3. C
4. D

7-62. The A-6 wing slat system and the leading edge wing flaps on the F-4 have the common function of providing
1. stability at lower speeds only
2. both additional lift and stability at lower speeds
3. stability at higher speeds only
4. both additional lift and stability at higher speeds

Learning Objective: Indicate operating characteristics and related component functions of the A-4 fuselage speed brake system, and recognize how some aileron trim control systems operate in specified conditions.

7-63. Why do A-4 fuselage-type speed brakes include an interconnect of cables and springs with the aircraft's nosedown elevator cable?
1. To prevent the aircraft from assuming a nosedown attitude when speed brakes are applied
2. To assist the pilot in bringing the aircraft's nose up when speed brakes are applied
3. To prevent the aircraft from assuming a noseup attitude when speed brakes are extended
4. To stabilize aircraft yaw when the speed brakes are applied

7-64. Which power source maintains the A-4 speed brakes in the extended position if the hydraulic system fails?
1. Separate electric motor
2. Externally introduced air under pressure
3. Entrapped hydraulic pressure
4. Spring tension

In items 7-65 through 7-67, select from column B the A-6 speed brake selector switch position which initiates the speed-brake system action described in column A.

A. System Actions	B. Switch Positions
7-65. Hydraulic fluid is blocked from both the extend and retract sides of the actuating cylinders to lock the speed brakes hydraulically	1. Forward 2. Centered 3. Aft 4. Neutral
7-66. Hydraulic fluid is ported to the extend side of the actuating cylinders to open the speed brakes	
7-67. Hydraulic fluid is ported to the retract side of the actuating cylinders to close the speed brakes	

7-68. Use figure 9-31 in your textbook. What common function is performed by the synchronizing mechanism linkage bungee and the torsional bungee assemblies at the wingtips?
1. Damage prevention if the linkage jams
2. Synchronization of speed brake extension
3. Speed brake retraction if the electrical system fails
4. Damage prevention through absorption of shock in the event of automatic retraction

Assignment 8

Maintenance of Flight Control, Actuating, and General Hydraulic Systems

Text: Pages 357-477

Learning Objective: Indicate procedures and precautions for removing and installing structural bolts, and purposes and techniques for torquing fasteners.

8-1. If the structural bolts cannot be removed by hand, during removal of an aircraft wing, what should you use besides a mallet to remove them?
1. A brass drift pin
2. A heavy bucking bar
3. Another bolt of the same size
4. An alignment pin

8-2. Refer to table 9-1 in your textbook. What is the maximum allowable tightening torque limit for a 3/8-16 cadmium-plated steel shear nut of the coarse thread series if the bolt has a tensile strength of 54,000 psi?
1. 170 inch-pounds
2. 240 inch-pounds
3. 275 inch-pounds
4. 390 inch-pounds

8-3. What will be the torque indicated on a 12-inch torque wrench employing a 6-inch drive-end extension to tighten a 9/16-18 shear nut to 500 inch-pounds?
1. 280 inch-pounds
2. 333 inch-pounds
3. 480 inch-pounds
4. 500 inch-pounds

Learning Objective: Indicate procedures and limitations for leveling and aligning aircraft and aircraft structures.

8-4. If the leveling lugs of an aircraft are damaged and repaired, the accuracy of their alignment can be cross-referenced with a
1. surveyor's transit
2. plumb bob only
3. spirit level
4. plumb bob and a datum plate

8-5. In a wing twist check of the RA-5C, what are the acceptable upper and lower limits for wing twist when the longitudinal reading is 1 degree, 42 minutes?
1. Upper-1 degree, 2 minutes;
   lower-1 degree, 22 minutes
2. Upper-1 degree, 22 minutes;
   lower-2 degrees, 22 minutes
3. Upper-2 degrees, 22 minutes;
   lower -1 degree, 2 minutes;
4. Upper-2 degrees, 22 minutes;
   lower-1 degree, 22 minutes

Learning Objective: Recognize functions, operating characteristics, and maintenance of various components of the rotary flight control system of the SH-3A helicopter.

8-6. Refer to figure 9-39 in your textbook. What is the sequence in which movement of the cyclic pitch control stick is transmitted to the rotary wing blades?
1. Cyclic pitch control stick → primary servocylinders → mixing unit → auxiliary servocylinder → rotary wing blades
2. Cyclic pitch control stick → auxiliary servocylinder → mixing unit → primary servocylinders → rotary wing blades
3. Cyclic pitch control stick → mixing unit → auxiliary servocylinder → primary servocylinders → rotary wing blades
4. Cyclic pitch control stick → primary servocylinders → auxiliary servocylinder → mixing unit → rotary wing blades

8-7. All of the following helicopter flight control system components are used to control the helicopter's heading EXCEPT the
1. mixing unit
2. primary servocylinders
3. pilot's foot pedals
4. auxiliary servocylinders

8-8. Sudden heading changes are restricted by a pedal damping piston in which bank of the auxiliary servocylinder?
1. Lateral
2. Collective
3. Directional
4. Fore-and-aft

8-9. Which component of the swashplate assembly directly transmits the movements to change the angles of incidence of the rotary wing blades?
1. Rotating scissors
2. Rotating swashplate
3. Stationary scissors
4. Stationary swashplate

8-10. When tracking blades after installation, you must set each adjustable pitch control rod to the pretrack number stenciled on the underside of the blade. If this number is PLUS and the adjustable pitch control decal indicates that it is set at 0, you must loosen the locknut and
1. lengthen the rod by rotating the tang clockwise
2. lengthen the rod by rotating the tang counterclockwise
3. shorten the rod by rotating the tang clockwise
4. shorten the rod by rotating the tang counterclockwise

Learning Objective: Recognize the operational characteristics, component functions, and troubleshooting procedures of the A-6 aircraft wing fold and spread system.

- Items 8-11 through 8-17 refer to the A-6 wing fold and spread system.

8-11. Which of the following conditions will prevent operation of the system?
1. Slats retracted
2. Flaps retracted
3. Control stick in the neutral position
4. Flight hydraulic system not pressurized

8-12. The speed of operation of the wing fold cylinders is controlled by
1. flow regulators installed in the spread and fold lines
2. dashpots installed in both ends of the cylinders
3. check valves installed in the spread lines
4. restrictors installed in the cylinders

In items 8-13 through 8-15, select from column B the function performed by the component listed in column A.

	A. Components	B. Functions
8-13.	Wing lock timer valve	1. To lock the wings in their spread position
8-14.	Wing fold cylinders	2. To lock the wings in their folded position
8-15.	Wing lock cylinders	3. To spread and fold the outer wing panels
		4. To synchronize the wing lock operation

8-16. To relieve thermal expansion, a relief valve is built into
1. each wing fold actuating cylinder
2. the pressure line downstream of the wing lock selector valve
3. the pressure line downstream of the wing fold selector valve
4. the pressure line of the wing fold and wing lock selector valves

8-17. If the wing lock warning flags fail to retract, the mechanic should consider this an indication of
1. all lockpins failing to properly enter the wing lock fittings
2. a defective wing lock timer valve
3. insufficient hydraulic pressure
4. a defective wing fold cylinder

Learning Objective: Recognize operational characteristics and component functions of the C-2 aircraft wing fold and spread system.

● Items 8-18 and 8-19 refer to the C-2 wing fold system.

8-18. All but which of the following statements relative to this system are true?
1. Both electrical and hydraulic power are required to spread the wings
2. The selector valve can be manually or electrically controlled from the cockpit
3. In an emergency the wings can be folded regardless of the position of the flaps
4. The wings can be folded without the use of electrical power by manual control of the selector valve

8-19. What prevents movement of the wing fold lock lever to the locked position prior to the wings being fully spread?
1. Trapped hydraulic pressure in the wing spread pressure release valves
2. Trapped hydraulic fluid in the wing lock cylinders
3. The wing lock-lock safety latches
4. The timer valve

8-20. Refer to figure 10-7 in your textbook. When the wing fold selector valve is actuated to the fold position, pressure enters this valve through
1. C1 and leaves through P2
2. C2 and leaves through P2
3. P2 and leaves through C2
4. P1 and leaves through C1

Learning Objective: Identify component functions and operational characteristics of the A-5 wing fold/tail fold systems and refueling probe system.

In items 8-21 through 8-24, select from column B the component which performs the function listed in column A.

A. Functions	B. Components
8-21. To control the actuating speed of the actuators	1. Sequence valve
8-22. To lock the wings in the fold position by trapping fluid in the fold line	2. Restrictor valve
8-23. To control pressure to the extend port of the lock cylinders	3. Wing fold lock and dump valve
8-24. To permit manual folding of the wing panels without hydraulic power	

8-25. Refer to figure 10-13 in your textbook. Which component prevents retraction of the probe until the lockpin has been retracted?
1. Priority valve
2. Lockpin sequence valve
3. Retract sequence valve
4. Doors close sequence valve

Learning Objective: Identify component functions of the P-3A windshield wiper system.

In items 8-26 through 8-28, select from column B the component which performs the function listed in column A.

A. Functions	B. Components
8-26. To convert the linear motion of the double piston to reciprocating action of the drive shaft	1. Speed control valve
8-27. To supply fluid directly to the window units through the hydraulic actuator inlet port	2. Return line check valve
8-28. To supply fluid alternately to the opposite sides of the window unit double piston	3. Window unit
	4. Hydraulic actuator

Learning Objective: Recognize component functions of the T-39 ac generator drive system.

8-29. When the system is first shut down, which component ports motor return fluid back to the drive motor inlet to prevent cavitation of the motor?
1. Heat exchanger check valve
2. System shutoff valve
3. Start valve
4. Governor

8-30. When the motor inlet pressure is 3,000 psi, the function of the start valve is to
1. reduce hydraulic pressure to the governor servo valve
2. connect the larger rack-actuated piston to a return passage
3. reduce hydraulic pressure to the smaller rack-actuated piston
4. expose the larger rack-actuated piston to control pressure from the governor

Learning Objective: Recognize operational characteristics and component functions of the SH-3A automatic blade-folding system.

8-31. After the blades are folded, the damper-positioners are kept in the autorotative position by
1. the blade positioner drive unit
2. the blade fold lock cylinders
3. the control lock cylinders
4. hydraulic fluid trapped in the rotary wing head

8-32. When do the control lock cylinders unlock the controls during the spreading operation?
1. As the blades start to spread
2. After the blade lockpins have extended
3. Prior to engagement of the rotor brake
4. As the blade positioner drive unit disengages the rotor brake disc

In items 8-33 through 8-36, select from column B the component which performs the function listed in column A.

	A. Functions	B. Components
8-33.	Maintain hydraulic pressure in the rotary wing head to keep the blades locked in the folded position	1. Blade fold accumulator 2. Rotor coupling
8-34.	Prevents hydraulic pressure from entering the blade fold system during flight	3. Safety valve
8-35.	Transfers hydraulic fluid to the rotary wing head for blade folding	
8-36.	Dampens out pressure surges during the fold and spread cycles	

Learning Objective: Identify characteristics, components, and operation of C-2 cargo doors and ramp-actuating system.

8-37. How is the ramp-loading selector valve actuated to the level position when the cockpit controls are used to raise the ramp from the ground to the fully closed position?
1. Hydraulically
2. Electrically
3. Mechanically
4. Manually

8-38. An emergency pneumatic system can be used to unlock and open the
1. ramp
2. side doors only
3. center door only
4. center door and side doors

8-39. What stops the ramp at the level position when it is lowered from the fully closed position?
1. The bottoming of the piston in the outer cylinder of the coaxial ramp actuator
2. The bottoming of the piston in the inner cylinder of the coaxial ramp actuator
3. The ball lock feature in the outer cylinder of the coaxial ramp actuator
4. The ball lock feature in the inner cylinder of the coaxial ramp actuator

8-40. What is the function of the interport bleed passage in the cargo door and ramp selector valve when the valve is in NEUTRAL?
1. To prevent ramp creepage
2. To prevent a hydraulic lock
3. To bleed entrapped air from the system
4. To prevent damage to the system by thermal expansion of the hydraulic fluid

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Learning Objective: Recognize principles of operation, component functions, and maintenance procedures for various hydraulically operated actuating systems.

8-41. The thermal relief valve downstream of the selector valve functions when the radome is
1. open and the selector valve is in OPEN
2. open and the selector valve is in NEUTRAL
3. closed and the selector valve is in CLOSED
4. closed and the selector valve is in NEUTRAL

8-42. Which component prevents pressurizing the radome system when other systems powered by the auxiliary hydraulic system are operated?
1. Flow regulator
2. Check valve
3. Radome selector valve
4. Hand pump selector valve

8-43. How is the canopy seal control valve positioned to control the inflation and deflation of the canopy seal?
1. Mechanically to inflate and deflate
2. Electrically to inflate and mechanically to deflate
3. Mechanically to inflate and hydraulically to deflate
4. Hydraulically to inflate and electrically to deflate

8-44. How many servo valves and actuators are normally required to position the antenna in a radar antenna drive system that uses hydraulic pressure?
1. Two servo valves and one actuator for each antenna
2. One servo valve and one actuator for each antenna
3. Two servo valves and two actuators for each antenna
4. One servo valve and two actuators for each antenna

In items 8-45 through 8-48, select from column B the component which performs the function listed in column A.

A. Functions

8-45. Supplements the bellmouth bypass system at low airspeeds

8-46. Controls secondary air bypassed around the engine for cooling

8-47. Prevents over temperature and/or reverse airflow in the engine compartment during ground operations

8-48. Positions the ramp through mechanical linkage

B. Components

1. Actuator
2. Auxiliary air door
3. Bellmouth ring

8-49. The reflector door actuating cylinder unlocks and opens the door when hydraulic pressure reaches
1. 100 to 300 psi
2. 400 to 600 psi
3. 500 to 1,000 psi
4. 900 to 1,500 psi

● Items 8-50 through 8-54 refer to the SH-3A helicopter rescue hoist system.

In items 8-50 through 8-53, select from column B the component which performs the function listed in column A.

A. Functions

8-50. Controls the speed of the hoist when it is 5 to 7 feet from full up or down

8-51. Maintains constant pressure to ensure the hoist brake functions to disengage during cable extension

8-52. Routes fluid through the slow flow regulator (50 fpm) when energized

8-53. Stops the hoist automatically when it is fully extended or retracted

B. Components

1. Limit switch
2. Accumulator
3. Flow control valve

8-54. How many degrees of handle rotation are required to close the microswitches within the manual speed control valve to actuate the direction control valve?
1. 1 to 2
2. 3 to 5
3. 6 to 7
4. 7 to 9

8-55. What type of valve isolates both the normal and emergency systems in the P-3 bomb bay door system?
1. Selector
2. Control
3. Shutoff
4. Check

8-56. To ensure maximum safety during the operational test of the P-3 bomb bay system, how many men are required?
1. One
2. Two
3. Three
4. Four

Learning Objective: Recognize installation and repair procedures for aircraft tubing and tube fittings.

8-57. Permaswage repair procedures are restricted to use at which maintenance level, if any?
1. Organizational
2. Intermediate
3. Depot
4. None

8-58. During Permaswage repair, the ratchet, rollers, and cutter wheel should be lubricated with
1. hydraulic fluid
2. oil, general-purpose
3. drycleaning solvent
4. petrolatum

8-59. The chamfer of the tube end after deburring shall be a maximum of
1. 1/4 of the wall thickness at an angle no less than 45°
2. 1/2 of the wall thickness at an angle no less than 33°
3. 1/4 of the wall thickness at an angle no greater than 33°
4. 1/2 of the wall thickness at an angle no greater than 45°

8-60. Proper use of the correct dash (-) size D9892 inspection gage for swaged fittings will ensure all of the following EXCEPT the
1. length of tube-to-fitting engagement
2. outside diameter of the swaged fitting
3. correct chamfer and maximum angle
4. length of the swaged portion of the fitting

8-61. How is acceptable minor damage to tube assembly fittings repaired?
1. Filed
2. Handstoned
3. Replated
4. Replaced

8-62. Which of the following tools is NOT part of the Rosan fitting installation kit?
1. O-ring installation tool
2. Combination lock ring wrench and drive tool
3. Removal tool
4. Fitting adapter

8-63. During installation of a Rosan tube end adapter, any sudden increase in torque prior to bottoming may indicate that the
1. end fitting has not been properly lubricated
2. lock ring being used is of improper size
3. lock ring serrations and port serrations are not aligned
4. lock ring has broached the serrations in the port

8-64. With proper lubrication using a solid film lubricant on all sliding surfaces, Dynatube fittings are capable of being assembled and disassembled at least
1. 10 times
2. 20 times
3. 30 times
4. 50 times

8-65. When attaching Dynatube fittings by welding or brazing, what precautions should you take to ensure against high temperatures in the beam-sealing area?
1. Disassemble the fitting completely
2. Use low-temperature gas equipment
3. Use chill blocks in the area
4. Quench the heated area several times

8-66. When installing a flareless fitting without utilizing a torque wrench, what is the maximum the B-nut may be turned after you have bottomed it by hand?
1. 1/6 turn
2. 1/3 trun
3. 1/2 turn
4. 3/4 turn

8-67. Refer to figure 11-39 in your textbook. How many inch-pounds of torque are required on the tube nut fitted to a 1/2-inch OD aluminum alloy tubing used in an oxygen system?
1. 200-250
2. 250-400
3. 300-400
4. 450-525

Learning Objective: Recognize the results of hydraulic system contamination and detection procedures.

8-68. The likely result of allowing sludge to accumulate in a hydraulic system is that
1. system components will be damaged by abrasives
2. additional filtering units must be installed in the system
3. the clearances between moving parts will no longer provide filtering action
4. the fluid will lose certain desirable characteristics and system efficiency will be reduced

8-69. When a new valve is installed in a hydraulic system, what type of contamination will most likely result?
1. Sand
2. Rubber
3. Rust
4. Lint

8-70. Which of the following statements relative to the use of petrolatum (vaseline) as a lubricant for hydraulic system seals is true?
1. Its use is prohibited
2. It can be used on gaskets only
3. It can be used on packings only
4. It can be used on leather backup rings only

8-71. Refer to table 11-12 in your textbook. What is the maximum number of 10- to 25-micron particles/100 milliliter sample that is acceptable for aircraft and ground support hydraulic systems?
1. 5,360
2. 10,700
3. 21,400
4. 42.000

Learning Objective: Relative to hydraulic filter elements, identify construction features and procedures for testing and cleaning.

8-72. Refer to figure 11-45 in your textbook. What is the function of the perforated metal tube in the center of this filter element?
1. To hold the shape of the pleated fine wire mesh
2. To support the element under differential pressures
3. To prevent passage of particles larger than the filter rating
4. To accumulate the varnish deposits caused by high operating temperatures

8-73. Which of the following statements relative to the operation of the Model N-470 Ultrasonic Cleaning and Testing Machine is FALSE?
1. The temperature of the 1, 1, 1 trichloroethane used in the test tank should be maintained at 90° F ± 5
2. Operation of the ultrasonic generator should be terminated prior to removing the element from the clean tank
3. The temperature of the cleaning compound, MIL-C-6864-C, should not exceed 15° F below its boiling point
4. The temperature of the 1, 1, 1 trichloroethane used in the final cleaning bath should not exceed 145° F

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